The Innovative Adaptation Structures of Agro-pastoral Communities to the Impact of Climate Change and Variability in Semi-Arid of Tanzania: A Case of Kiteto and Kilindi Districts

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Abstract

The study made an investigation on agro-pastoralists' resilience through innovative adaptation structures to the impacts of climate change and variability in semi-arid areas of Kiteto and Kilindi districts. Data were collected using household survey which sampled 384 households, Focus Group Discussion, In-depth interviews and field visits were also used to collect more detailed data. The results indicated that the majority of the respondents indicated the decline in grazing lands/pastures and water resources leading to the decrease in the number of livestock and crop productivity by about 91.1%) being the major effect of climate change and variability in the study areas. All these have resulted to food insecurity for about six years consecutively. Therefore, to increase resilience, agro-pastoralists have developed innovative adaptation strategies which varied from one village to another, however, most of them were similar in abating food insecurity and climate change vulnerability. Overall, the main innovated adaptation strategies in order of importance were seasonal mobility with their livestock, construction of traditional water points locally known as Njoro, the use of traditional by-laws for pastures conservation/rotational use, traditional Maasai constructed water reservoirs (Mboutu), reducing stock number by selling and women transporting water by donkeys from traditional wells/Njoro and all of which have increased their livelihoods in dry lands.

Key words: *Agro-pastoralism, climate change, climate variability, vulnerability, adaptation, Njoro, Mboutu*

Introduction

Climate change and variability is increasingly being recognized as a critical challenge to agro-pastoral production systems in the arid and semi-arid rangelands, and it has become a burning issue because of its effects on human lives and the future food security of the world (FAO, 2007). The rate of changing climate is not uniform around the globe and the magnitude of change varies in spatial temporal distribution (Agrawala *et al*., 2003). The global

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surface temperature has warmed up by 0.8°C in the past century and 0.6°C in the past three decades (IPCC, 2001). Still it is projected that if greenhouse gases emissions (GHE) remain the leading cause of climate change and variability, the mean annual global temperature will increase by 1.42°C—5.82°C by the end of the 21thcentury (IPCC, 2007) whereby agro-pastoral communities will be more affected, although trends will vary widely by region and over time. The decrease in precipitation and increase in temperature has occurred in the Sahel, the Mediterranean, southern Africa and parts of southern Asia affecting the livelihoods of rural societies, food security in particular (NAPA, 2006). In North Africa and the Sahara regions, annual mean temperatures are expected to increase by the median values of 3.5°c and 3.6 °c, respectively with the largest increases expected during the summer months of June, July, and August (NIC, 2009). Reports from the World Bank (2006) and Bank of Tanzania (2008) showed that there was a decline in the contribution of agriculture and livestock sub-sector to GDP from 45.1% in 2000 to 26.7% in 2007 due to changes in climatic parameters and other non-climatic stressors like land use/cover changes.

The continent of Africa is the second driest in the world after Australia and about 60% of its population dwell in the driest rural areas and mostly depending on rain fed, small scale agriculture partly forming an agro-pastoralism system (Tran, 2011).). There is a widespread scientific consensus that the African continent is currently warmer than it was 100 years ago. Hence, arid and semi-arid rangelands which support over 50% of the world's livestock and provide forage for both domestic and wildlife populations are under stress due to global changing climate as well as inappropriate tenure policies affecting food security of pastoral communities (Briske & Heitschmidt, 1991).

The African continent is already facing critical food shortage because of increased, recurrent droughts, floods and other socio-economic factors in various parts of the continent. For example, on 2010 out of 22 countries identified by FAO having high food insecurity worldwide, about 17 of these countries were from sub-Saharan Africa, Tanzania in particular mainly due to the prevalence and recurrence of natural disasters like droughts, floods, diseases and increased dryness (FAO, 2010a). Also, FAO (2010b) estimated that in the year 2010-2011, about 350 million people especially dwelling in semiarid climates like agro-pastoral communities were highly affected by drought and other natural disasters worldwide and those from Sub-Saharan Africa were mentioned to be among the mostly affected and experienced serious food-insecurity.

It is estimated also that one third of people in Africa already live in drought-prone areas and 220 million are exposed to drought each year and are highly vulnerable to food insecurity (IPCC, 2007b). Agro-pastoralism is a main determinant of food security in semi-arid areas, hence climate change and variability has been affecting livestock through different ways like decline in water resources, prevalence of new (vector-borne) livestock diseases and pests, decline in quality and quantity of pastures and forage crops, and free-grain production (Rötter and van de Geijn 1999, West 2003, White *et al.* 2003, Thornton *et al*. 2009; PCC, 2007) and all these have negatively affected livestock production. Therefore, livestock keeping systems in Africa face multiple stressors that interact with climate change and variability which amplify vulnerability in dry lands. These stressors include rangeland resources degradation, increased variability in access to water resources, fragmentation of grazing areas, changes in land tenure from communal toward private ownership; in-migration of non-pastoralists into grazing areas; lack of opportunities to diversify livelihoods; Solomon *et al.,* 2007, 2008). However currently, mass loss of livestock under prolonged drought conditions is more critical risk given the extensive rangeland in Africa than other non-climatic conditions.

In East Africa, thousands of agro-pastoralists herd their livestock in the semi-arid to arid areas. Climate analysis suggests that there are high differential in the impacts of climate change and variability (Thornton *et al.,* 2009b). For example, parts of East Africa have become drier, with considerable reduction in the length of the growing season, pastures deterioration and decreased food productivity especially among Maasai pastoral communities who are custodian of semi-arid climates. According to FAO, (2008) climate change and variability make food security more vulnerable because it affects food systems.

Tanzania is endowed with a livestock resources and ranks first in the Southern African development community (SADC) and East African Communities (EAC) and third in Africa in terms of cattle population. The estimated livestock population amounts to 19.5 million cattle, 13.8 million goats, 3.7 million sheep and 45 million indigenous chickens (Economic Survey, 2011; Tanzania National Census of agriculture, 2012). Meanwhile, rangeland resource is estimated at 61 million hectares of which about 44 million hectares are for grazing and 17 million hectares are fallow and forestland. According to Mwakaje (2013), Tanzania has a total of 17.4 million cattle and 98% of these are in the hands of pastoralists and agro-pastoralists involving about 2.2 million people. Out of this, about 80% of these livestock are kept in the agro-pastoral system while 14% are in the pastoral system (URT, 2006; Mwakaje, 2013). For

instance, the predominant livelihoods for populations in Kiteto district are: agro-pastoralism (60%), agriculture (22.8%), and pastoralism (17.2%) (CICERO Report, 2015:02).

The ongoing climate change and variability is likely to have effects on agro-pastoral communities more negatively because they are already living in marginal lands, hence frequently becomes food insecure (Mwakaje, 2013). It is estimated that 3% of households in Tanzania are pastoralists and 7% are agro-pastoralists, hence a study on effectiveness of agro-pastoral community's innovative adaptation strategies in this era of changing climate is very significant. Furthermore, studies show that rural dwellers in semi - arid and arid areas are more vulnerable to the impacts of climate change and variability than their counterparts due to the decline in livestock and crops growing. In regions like Dodoma, Manyara, Shinyanga and Singida it is predicted to experience higher temperature ranges (Mwandosya and Luhanga, 1998; Shemsanga, 2010; FAO, 2008). Moreover, there will be a reduction of rainfall by about 20% which will cause dry seasons to be longer than normal (Mwandosya & Luhanga 1998; Hulme *et al.,* 2001; IPCC, 2007). In the years2006, 2009, 2011 and 2013 Tanzania lost cattle between 3,000 and 4,000 due to prolonged droughts.

Currently, livestock keeping is a central livelihood activity to agro-pastoralists in Kiteto and Kilindi study districts that rely on it for income generation mainly from sales of milk, meat and blood consumption (Sangeda and Malole 2014).Therefore, these semi-arid districts are among the most vulnerable districts in the country because of high dependence on this climate sensitive livelihood activity with low adaptive capacity. Climate stress affects the study districts in terms of amount, patterns and distribution of rainfall, longer dry spells and droughts and low livestock production through decreasing grazing land and water resources and damaging of crops (Sangeda *et al* 2013) all resulting to food shortage (Liwenga *et al* 2003; Kangalawe & Liwenga 2005).

Therefore, the extent to which increased heat stress associated with climate change and variability particularly in the arid and semi-arid areas as well as in the tropics and subtropics has not been well established (Thornton *et al.,* 2009b). Hence, although few studies point the possibility that keeping heat-tolerant livestock is more prevalent in response to warming trends, still productivity of livestock has been down with reduced crops growing. This calls for effective and efficient adaptation practices which will improve more livestock and crops productivity and improved food security among agro-pastoral communities.

In response to these adverse effects, agro-pastoral communities in the semi-arid areas have been employing various traditional adaptation strategies through their indigenous knowledge systems because of lack of access to modern-day practices and measures to survive under the changing climate and variability such measures are like extending the cultivation of land into marginal areas, increased mobility, mixed cropping, pastures conservation, off-farm/livestock keeping. However the efficacy of all these innovated structures in guiding future adaptation strategies in accordance with the projected extreme events of climate change and variability is not clearly understood. The present study therefore focused on assessing the efficacy of designed innovated adaptation strategies applied to the impacts of climate change and variability in Kiteto and Kilindi districts as a basis for achieving sustainable development among agro-pastoral households in arid and semi-arid dry land areas. It aims to inform practitioners and policy makers to take appropriate measures to address the challenges by integrating local and scientific strategies to ensure sustainable environment and food security. Specifically therefore, the study intended to investigate and assess the efficiency of traditional knowledge innovated adaptation strategies by agro-pastoral community applied to climate change and variability impacts in order to improve livestock and crop productivity and household's food security.

Materials and Methods

Geographical Description of the Study Areas

Kiteto district is located in northern Tanzania *in* Manyara region and covers an area of 16,685 square Kilometers whereby most of the land is potential for animal keeping (Pastoralism) and crop growing. It lies between Latitudes 04^0 36'00''and 06^0 7'30'south of the Equator and Longitudes 36^0 33'00'' and 37^0 36'00''East of the Greenwich It lies between 1,000m – 1,5000m above sea level (KDC, 2017) (see Fig.1). Meanwhile Kilindi district is located south west of Tanga region covering 6,129 $km^{2.}$ It lies between latitudes 5^0 18'00''and 6^0 48'00''south of the Equator and Longitudes 37^0 $55^0$15'00'' and $38^0$45'00''E east of the Greenwich. It covers an area of 6443.52km^2 land whereby 47% is potential for animal keeping mostly and agriculture mostly in good soils (KDC, 2017).

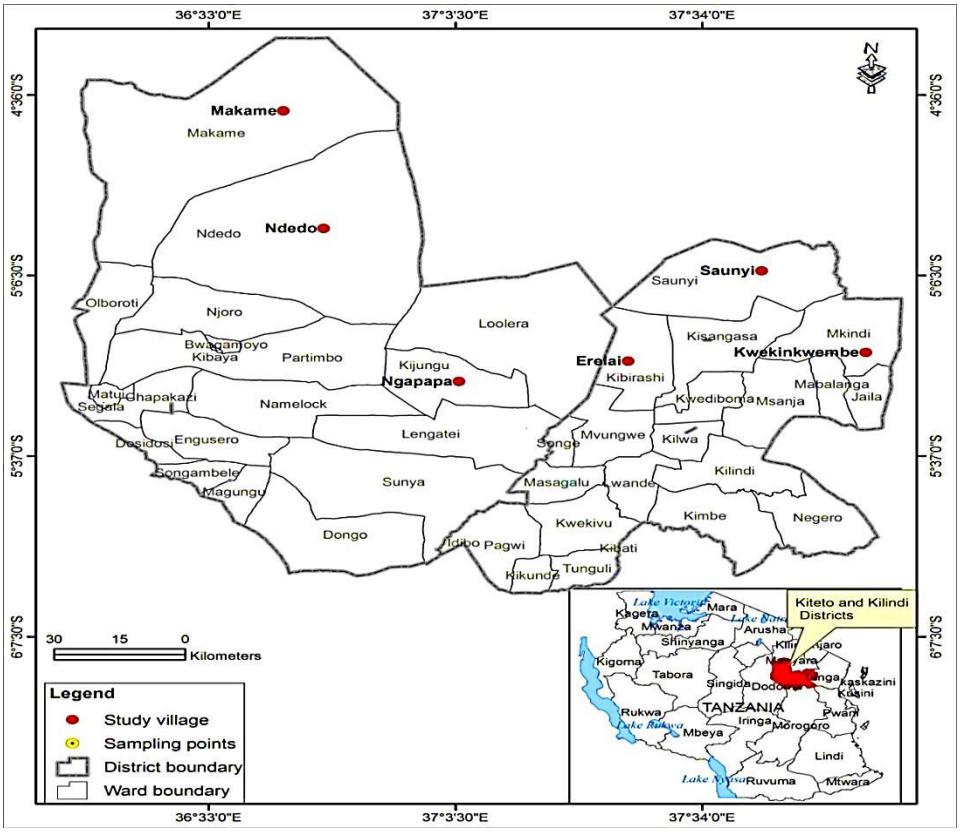

Figure 1: Kilindi and Kiteto Districts Administrative areas and the Sampled Study Villages

Source: Field Survey 2018

Climate

Kiteto district is generally considered to have arid to Semi – arid f climate. The average emperature in the district is 25°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 pa. Meanwhile Kilindi district is semi-arid with an average annual rainfall of 500mm ranging from 400mm to 700mm, temperature ranges from 13^{o}c to 30^{o}c. It has dual periods of unreliable rain seasons comprising of 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 (KDC (2017) (see Figure 2).

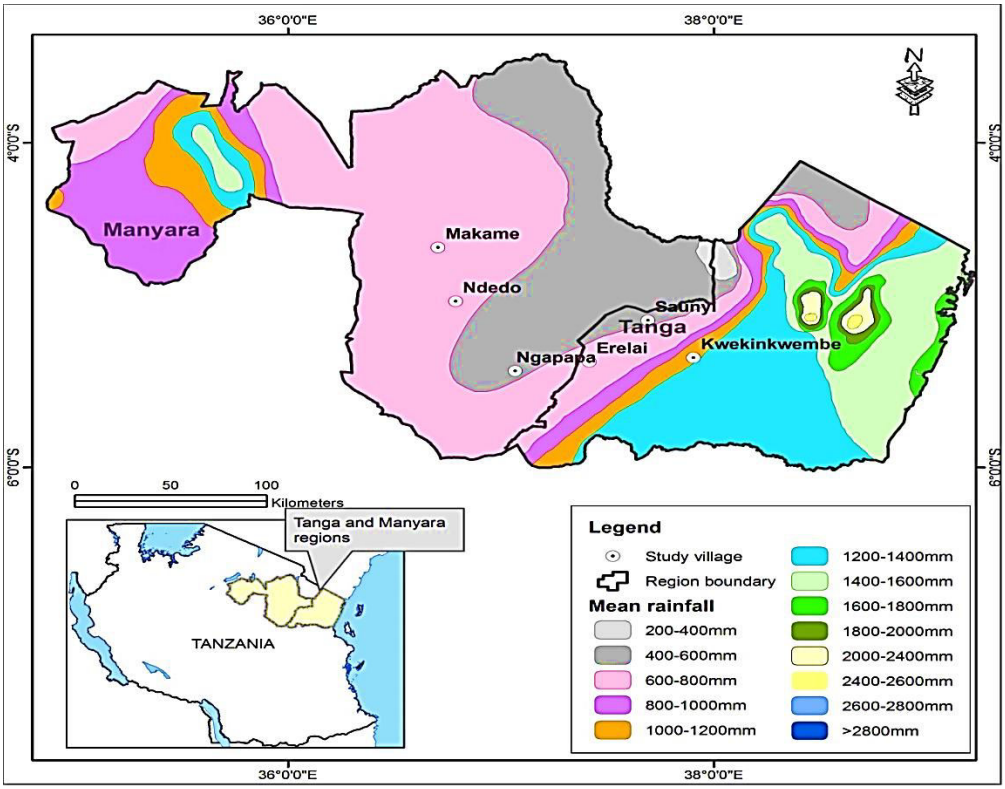

Figure 2: Rainfall Distribution in Kiteto and Kilindi districts
Source: Field Survey 2018

Data Collection Methods

Primary data was the main source of information for this study based to qualitative and quantitative approaches and were also collected through focus group discussion, in-depth interviews, field observation and wealth ranking and structured questionnaires for socio-economic survey.Secondary information/data was obtained from published and unpublished documents and reports, from different sources like the Ministry of Agriculture, Food and Cooperatives; District Agricultural and Livestock Development Offices (DALDOs) different publications, books, theses and journals from the libraries of University of Dar es Salaam (UDSM), Institute of Resource Assessment (IRA), government policy documents and and websites. In all, information collected were perceptions, impacts, vulnerability and adaptation (Majule *et al.,* 2009).

Socio-economic activities of the study districts

Livestock keeping is a primary livelihood activity carried out in Kiteto district. The economy of this district depends almost entirely on livestock and crop

farming in a small scale. Animals kept are cattle, goats, sheep, donkeys and chicken which are mostly kept by Maasai communities. The major crops grown are maize, beans, sunflower, cassava, millet and finger millet. Agro-pastoralism in the district accounts to 60% while 22.8% is crop growing and pure pastoralism consist of 17.2% hence making agro-pastoralism the most dominant livelihood activity. Nonetheless, agriculture is characterized by low productivity due to unreliable rainfall (URT, 2007c; BDC, 2006).

On the other hand, in Kilindi district agriculture is a primary activity followed by animal keeping. It is reported that agriculture accounts for more than 60% and has the largest number of smallholders who also keep animals (agro-pastoralists) (40%), and it is graded as the main producer of food crops in the region by the National Food Reserve Authority (NFRA) has singled in Tanga region (URT, 2012). This implies that the majority of the people in the area are smallholders depending on agro-pastoralism which in turn depends on rain-fed agriculture which is so vulnerable to climate change and variability effects. The major crops grown are maize, beans, sunflower, cassava, sweet potatoes, millet and finger millet, mangoes, bananas, sugarcane. However currently there is introduction of new crops like cashewnuts, Haricot beans, pigeon peas and cowpeas as drought resistant crops and animals kept are cattle, goats, sheep and donkeys. Above all the study was confined to two agro-pastoral districts namely Kiteto and Kilindi districts, taking three wards from each district basing on different agro-ecological zones. About six study villages were selected, one village from each ward, namely Saunyi, Kwekikwembe, Erelai, Makame, Ndedo and Ngapapa.

Results and Discussion

Characteristics of the study areas

The occupation performed by the household heads determines the income levels which in turn, influence vulnerability of the household to climate change and variability effects. The results in Table in Table 1) indicate that the majority (44.4%) were pure pastoralists and the remaining were the said agro-pastoralists (37.5%) and other non-farming activities. Basing on income levels in the study areas, the agro-pastoralists were wealthier than livestock keepers only thus being able to easily adapt to climate change and variability and food insecurity. However, the agro-pastoralists were able to sell part of their livestock to buy food in time of crop failure; the agro-pastoralists were much food secures than pure livestock keepers.

Table 1: Respondent's occupation in the study disticts

Economic Activities	Districts												Total N=384	Total %
	Kiteto						Kilindi							
	Ndedo		Makame		Ngapapa		Kwekinkwembe		Saunyi		Erelai			
	N	%	N	%	N	%	N	%	N	%	N	%		
Livestock keeping only	38	55.1	33	37.1	25	55.6	19	15.1	62	65.4	29	67.4	**206**	**44**
Both livestock keeping and crops growing	11	15.9	41	46.1	17	37.8	71	56.3	20	21.4	14	32.6	**175**	**37.3**
Casual labour	0	0		0	0	0	2	1.6	2	2.2	0	0	**4**	**0.8**
Petty business	5	7.2	6	6.7	1	2.2	10	7.9	2	2.2	0	0	**24**	**5.1**
Wage employment	0	0	0	0	0	0	1	.8	1	1.1	0	0	**2**	**0.4**
Beekeeping	4	5.8	3	3.4	0	0	6	4.8	1	1.1	0	0	**14**	**3**
Mining	0	0	0	0	0	0	1	.8	1	1.1	0	0	**2**	**0.4**
Arts Craft works	1	1.4	1	1.1	0	0	4	3.2	1	1.1	0	0	**7**	**1.4**
Making and selling charcoal	2	2.9	1	1.1	1	2.2	1	.8	1	1.1	0	0	**6**	**1.2**
Collecting and Selling firewood	4	4.4	0	0	0	0	5	4.0	0	0	0	0	**8**	**1.7**
Hunting	5	7.3	4	4.5	1	2.2	8	4.7	3	3.3	0	0	**21**	**4.4**
Total	70	100	89	100	45	100	128	100	94	100	43	100	**469**	**100**

Source: Field Survey 2018

Household heads education levels

Education is important because it determines one's level of understanding and interaction with the environment (URT 2003). The findings indicated that the majority (76%) of the agro-pastoralists communities in the area had no formal education level, followed by holders of primary Education which was 17.7% while those with Adult Education were (3.6%) As a whole those with secondary education were 1.8% and very few had post-secondary education (0.8%) as shown in Figure 2. Also, almost all villages had the highest rate of illiteracy above 60% which in turn imply that they had low adaptive capacity on the effects of climate change and variability. This observation is similar to Deressa *et al*., (2008) who noted that, low level of education in Ethiopia represented low adaptive capacity to climate change and variability. Similar results were observed by Mwalukasa (2013) that reasonable education levels enable agro-pastoralists to receive and transmit farming and animal keeping education at local levels.

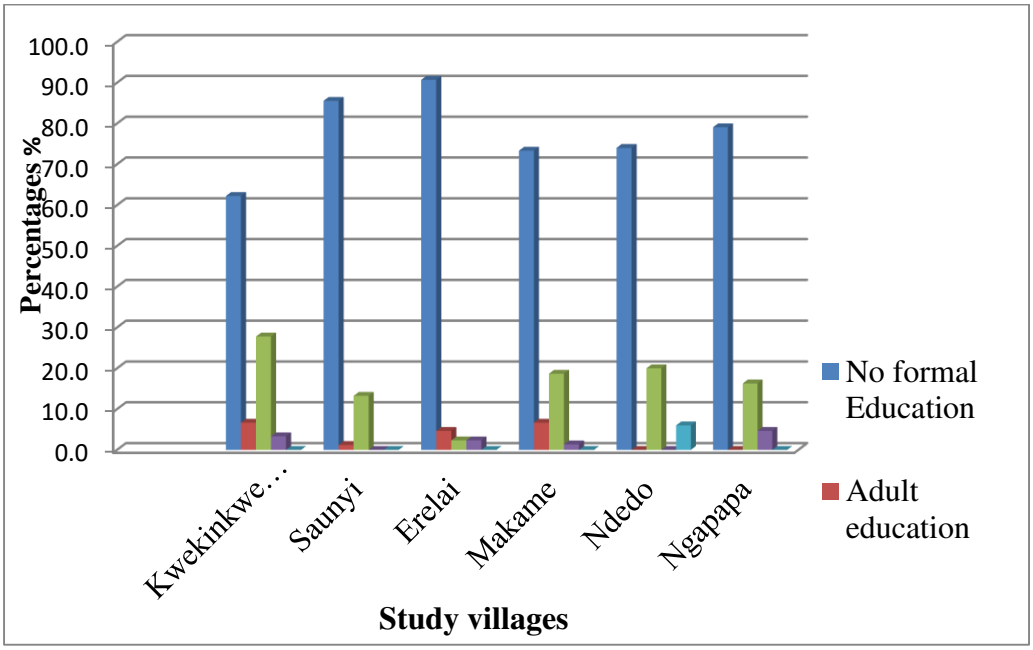

Figure 2: **Household heads education levels**
Source: Field survey (2018)

Agro-pastoralists perceived impacts of Climate Change and variability

Field results indicated that, climate change and variability impact in the study areas started to be felt by agro-pastoralists in the 1980s' and continues to be felt to date. It was also observed that all villages studied had been experiencing the impact of climate change and variability. Basing to the Table 2 which has been

analyzed through multiple responses and being based on agro-ecological location of a particular study village and household characteristics like education level and type of economic activity being highly sensitive to climatic stresses. The findings further indicated that the majority of the respondents mentioned the decline in the number of animals for about 91.1%) to be the major indictor of climate change and variability in the study areas. The decline in the number of animals indicated the extent of food insecurity that the people had been facing for six years consecutively more linked to the decrease in rainfall amount and duration which affects pastures and water availability to animals.

Moreover, increased droughts were noted to be the second felt impact indicator mostly pointed by 89.1% of the respondents. The respondents linked increased droughts as has been existed for a very long time in a repetitive way which had great effect on water and pastures which forms a basis for their animal's food. Recurrent food shortage was also one among the major impact indictors of climate change and variability in Kiteto and Kilindi districts as pointed by 87.2% of the respondents. Respondents reported that, due to prolonged droughts which results to crop failure like maize and beans as well as deaths of their animals especially cattle and goats which they depend for food through meat, milk and blood. Therefore, they have been facing food insecurity since the 1990's because apart from depending on cattle for food directly, they sell them so as to buy other food sources like sugar and maize flour from shops. Now they are failing because of low income as the price of cattle and goats during dry season becomes very low.

Respondents further reported on the emerged new livestock diseases which were reported by 86.5% of the respondents. The agro-pastoralist emphasized that, nowdays due to changes of environment there is an emergency of new animal diseases which has led to deaths of large number of animals and these new diseases are like Rinderpests (Maasai locally known as Olodwa), Heart water (Maasai locally known Olmiro), Anaplasmosis (Maasai locally known as Emonywa), the old one which also have been killing animals are like Lung sickness CBPP (Maasai known as Olikipei), Tsetse fly/Ndorobo, Anthrax, East Coast Fever (Ndigana kali, ECF) and Foot and Mouth disease (Alerobi).

Moreover, respondents reported on increased temperature which were pointed by 71.1% of the respondents. The agro-pastoralist emphasized that, nowadays temperature is very high affecting the growing of pastures and constructed traditional wells for their animals and domestic uses. Respondents lamented that

nowdays dry spells have increased as compared to the previous years. Based on their experience, dry spells happened in February lasting for two to three weeks. Nowdays, dry spells are unpredictable as they exist even in January (crops and pastures growing season), thus affecting the whole growing season and pastures.

Decreased rainfall amount was also reported by 68.8% of the respondents. The decrease in rainfall was explained based on rainfall amount, duration and distribution. The agro-pastoralist reported that, nowadays the amount of rainfall received is not enough for crop growing and pastures as well as their constructed water wells to fill in water from rainfall sources as it used to be. Other indicators are outbreak of insect and pests, decreased crop productivity, outbreak human diseases, rainfall coming too late and shortened growing season. Basing on village-wise as comparative analysis, the following were mentioned as mostly felt impacts of climate change and variability to all study villages like decreased number of animals, recurrent food shortage, increased droughts, emerged new animal diseases and increased temperature (Table 2).

Table 2: Perceived Trends of Livestock Keeping in Kiteto and Kilindi districts

Trends of livestock keeping in 30 years	Frequency(n)	Percentage
Increasing	32	8.3
Decreasing	34	89.1
No change	6	1.6
Do not know	4	1.0
Total	**384**	**100**

Source: Field survey, 2018

According to livestock officer in Kilindi district stated that Kilindi district has about 216,240 ha of grazing lands which is about 35% of all lands in the district, farming land has 290,030 ha (47%), forest reserve 30,556 ha (5%) and open reserve 76,074 ha (13%), therefore large land is used for agriculture production, hence grazing lands has been encroached by crop producers, affected by Tsetse flies as well as persistent drought and therefore, land use planning in the district is of significance importance for proper and sustainable land management (key informant KLO).

Grazing/pastures Status in Kiteto and Kilindi districts

Reflecting districtwise changes, Kiteto district showed decreasing trend in grazing lands to all livestock category, whereby cattle pastures area (ha)

indicated very sharp decline in pasture areas. The notable decline is from 2004 with 1500000ha to 314900ha this is contributed by agricultural expansion and unreliable rainfall and increased droughts due to high temperature. The decrease in cattle pasture area is explained by 93% (R^2 =0.9303) of the observed variance for the entire study period and the decrease is by -1018.7 hectares y^{-1} (Figure 3). Also pastures/grazing areas for goats and sheep showed a decline, the decrease for goats pastures is explained by 89% (R^2 =0.8862) of the observed variance in the whole study period, and the decrease is by -60.586 hectares y^{-1} (Figure 3).

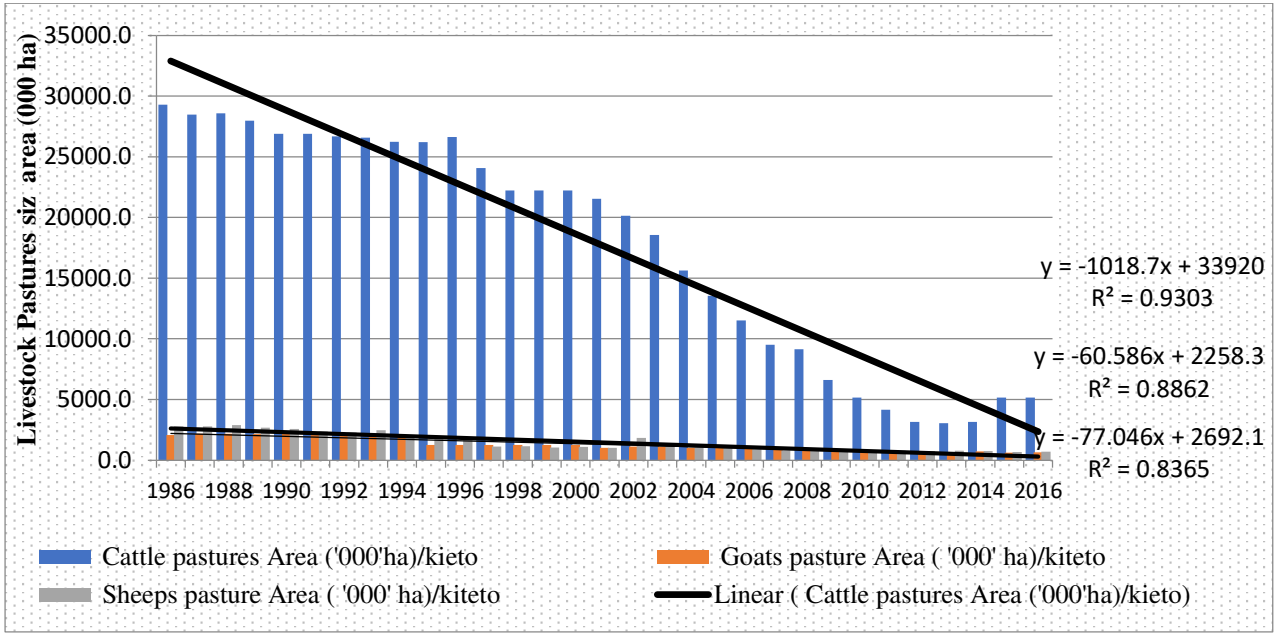

Figure 3: Trends of grazing land/pastures in Kiteto district from 1986 to 2016
Source: District Report, 2017

Kilindi district also indicated a decline in pasture areas among livestock categories except for goat's pastures which showed positive increase. The results further revealed the variability in grazing land, cattle pasture decrease is explained by 62.2% (R^2 = 0.6222) of the observed variance for the entire study period and the decrease is by -338.89 hectares y^{-1}(Figure 4). Also, sheep pastures area declined by 37.6% (R^2 =0.0376) of the observed variance for the entire study period and the decrease was by -338.89 hectares y^{-1} the decreased, while goats pastures area increased positively by 96.7%(R^2 =0.1377.3) of the observed variance for the entire study period (Figure 4). The increase is attributed by the fact that, goats are heat tolerant.

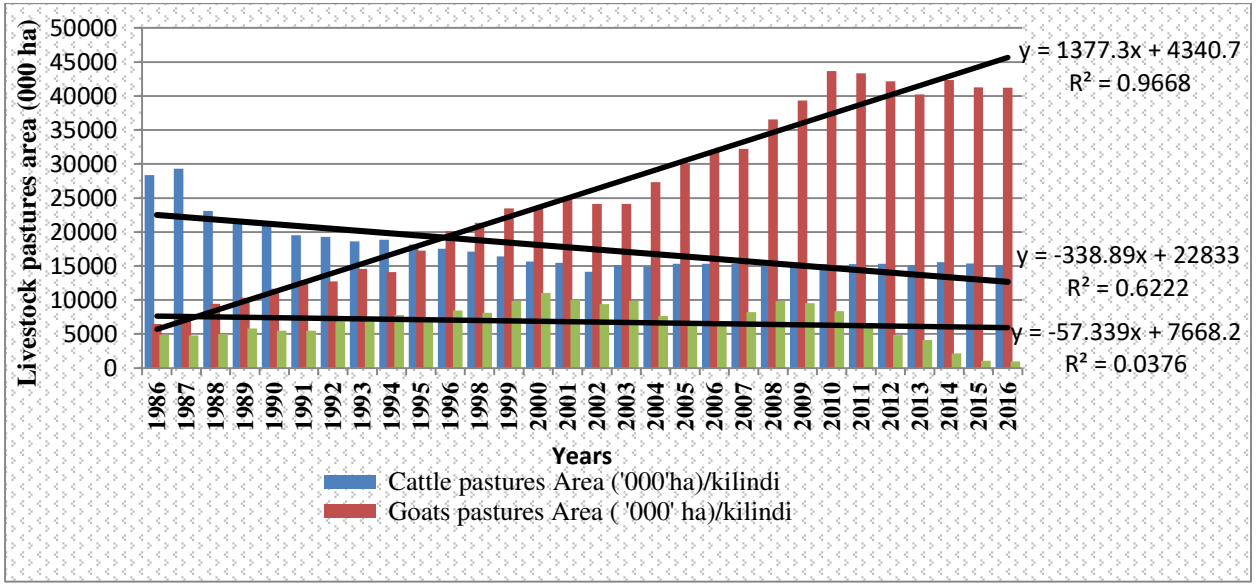

Figure 4: The status of pastures in kilindi district from 1986 to 2016
Source: District Report, 2017

Livestock population trends in the study districts

Trends in livestock production varied between districts and among types of livestock. The results from Figure 5 indicates negative decline in livestock population/numbers in Kiteto district specifically cattle and goats, while sheep and donkeys showed increasing trend. The results for cattle population revealed decreasing trend being explained by 14.5% (R^2 =0.0145) of the observed variance for the entire study period and the decrease was by -1168.2 hectares y^{-1}. Also, goats population showed deceasing trend by 11.9% (R^2 =0.0119) of the observed variance for the entire study period and the decrease was by -1018.8 hectares y^{-1} and this is reflected from the declining trends in grazing areas due to scarcity of pastures and water.

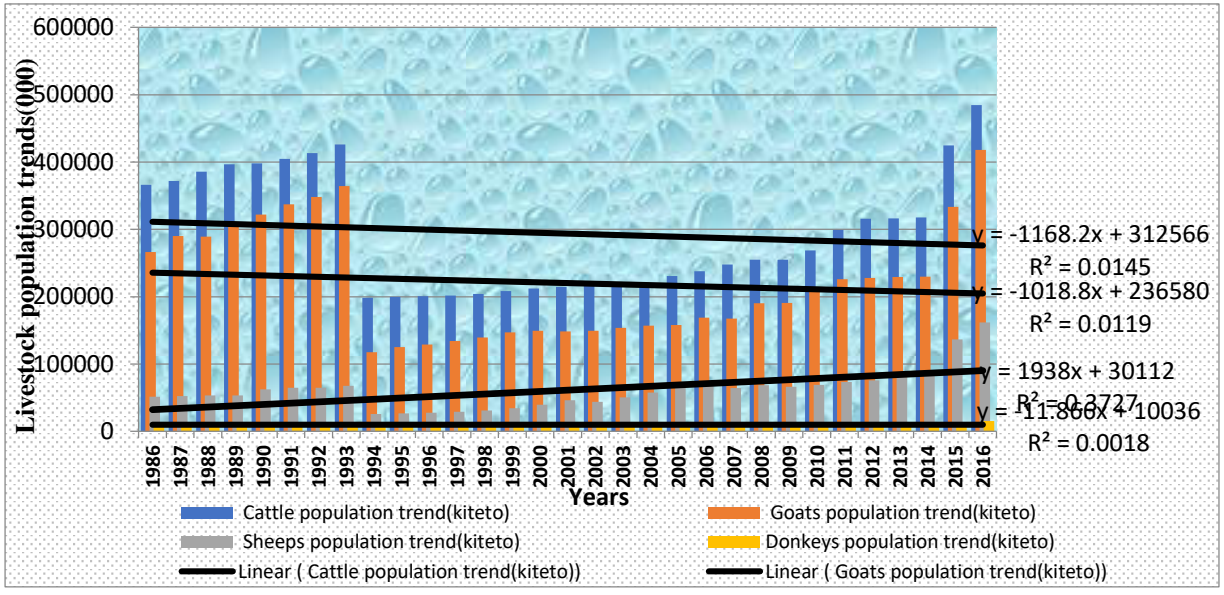

Figure 5: Livestock population patterns and trends for kiteto district, 1986 to 2016

Source: District report, 2017

Similarly, Kilindi district showed differentials in the trends of livestock whereby the results from Figure 6 indicated positive increase in livestock population specifically cattle and goats while sheep and donkeys showed decreasing trend. The results for cattle population revealed positive increasing trend being explained by 20.11% (R^2 =0.2011) of the observed variance for the entire study period and the increase was by 2557.6 y^{-1}. Also, goats numbers showed increasing trend by 83.53% (R^2 =0.8353) of the observed variance for the entire study period and the increase was by 6219.4 y^{-1}, and this is influenced by the mobility to nearby areas. However, in the case of goats the grazing areas thought the entire period of study had increasing trend. The number of donkeys in Kilindi district reflected decreasing trend which was caused by theft more related with the increase in donkey meat markets in Dodoma created by the Chinese immigrants. Also sheep numbers indicated declining trend by 5.6% (R^2 =0.0056) of the observed variance for the entire study period and the increased by -118.68 y^{-1} of the observed variance.

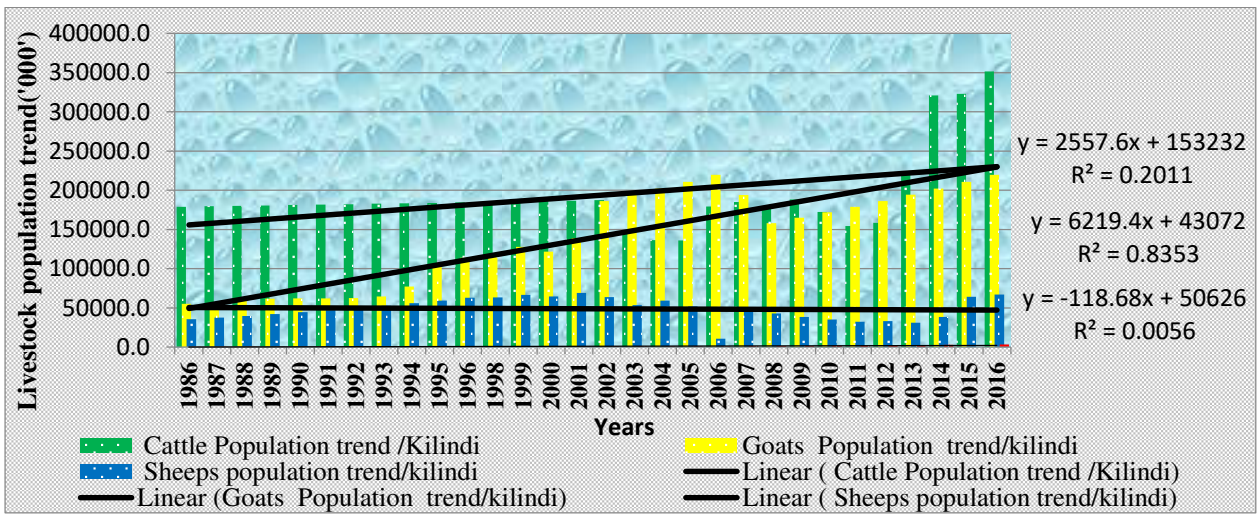

Figure 6: Livestock population patterns and trends for kilindi district, 1986 to 2016
Source: District report, 2017

Generally, livestock production had declining trend over the entire period of study, however the decline is not similar among livestock category as result impacting negatively food security of agro-pastoral communities.

The Agro-pastoral Community's Resilience and Innovative Adaptation Strategies to increase their Household's Livelihoods

The Agro-pastoral communities have been described as "masters of innovative traditional adaptation in dry lands", actively relying on variability to maximize animals productivity during periods of plenty and scarcity, and carefully managing rangelands during periods of food shortage (Msangi *et. al.,* 2014).The results of the study revealed that agro-pastoralists in the study areas employed a number of 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, emerged livestock disease and shortage of water and pastures. Increased resilience and innovative adaptation strategies ensure 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 innovated adaptation strategies in order of importance were seasonal migration of livestock, construction of traditional wells, the use of traditional by-laws for pastures conservation/rotational use, reducing stock number by selling and transporting water by donkeys from traditional wells (Figure 7).

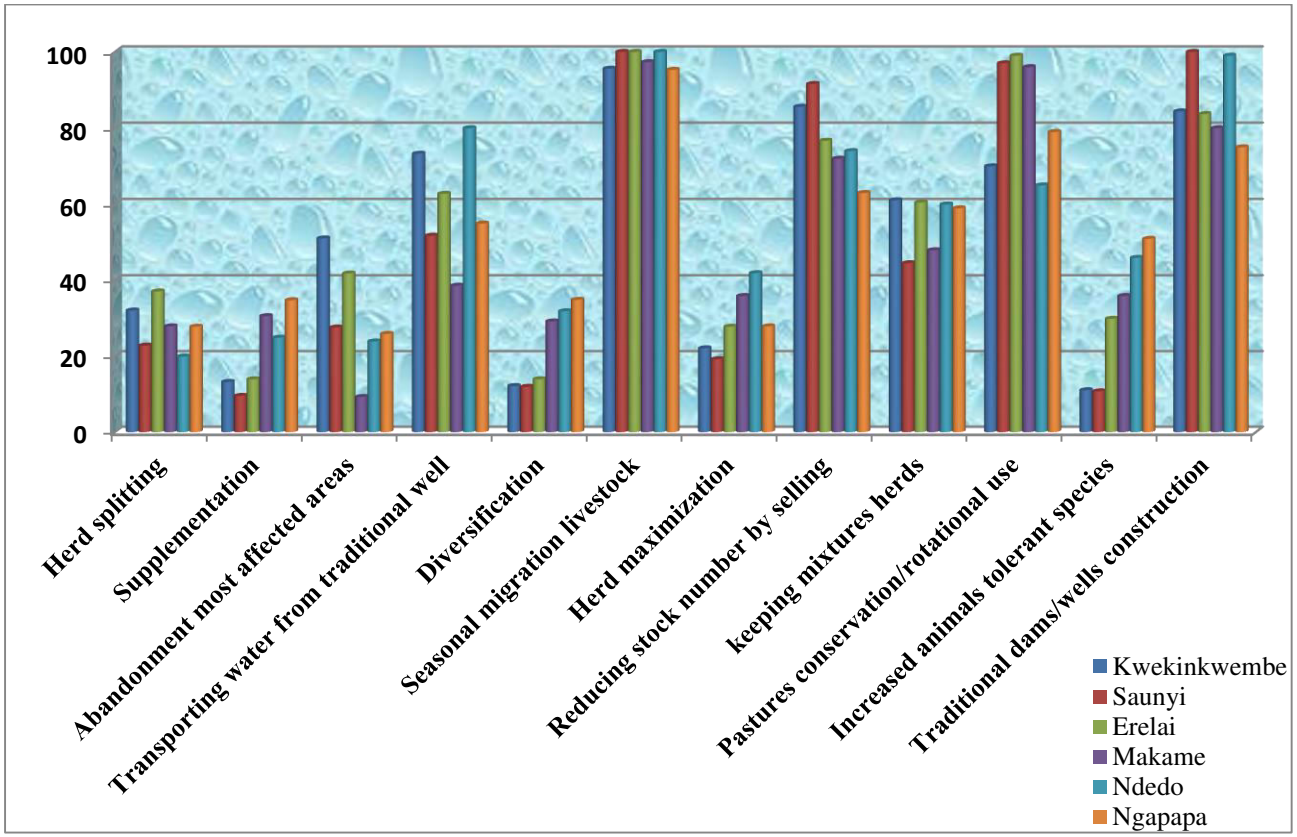

Figure 7: **Agro-pastoralist perceived innovated adaptation strategies among study villages**
Source: Field Survey, (2017)

Like in other parts of semi-arid areas of the world, agro-pastoralist in study villages implemented various measures in adapting to climate change and variability impacts. Villagewise the results indicated that seasonal migration with livestock was practiced by 90% but Saunyi, Erelai and Ndedo villages used seasonal migration 100% as adaptation to the impacts of climate change and variability due to adverse effects of droughts in these villages.

Seasonal migration with livestock to distant areas

Results from households, focus group discussion and key informants indicated that pastoralists migrate to distant areas in search of water and pastures during the dry seasons when water sources have been depleted and pastures dry up or are not enough to sustain their livestock in their areas. For example during FGD it was observed that since the 1980s pastoralist's mobility in search of water and pasture was increasing when compared to previous years as far back as the 1950's. The pastoralists' migration for search of pasture and water was classified into two categories: internal migration (within the country moving in short distances) and international (beyond country's borders or long distance movements) which was practiced by groups of pastoralists. Internally, pastoralists migrate to new emerging pastoralist regions and districts of Morogoro, Tanga, Coast, Dodoma, Iringa and Kilimanjaro regions and internationally the destination is Kenya and few migrate to Uganda and Zambia where sometimes their livestock are confiscated because of strigent emigration laws. In the process of outmigration or emigration they crash with smallholder farmers because they graze their livestock such as in Movemero and Kilosa districts sometimes leading deaths of both communities which was also observed by Mwamfupe and Mug'ong'o (2015) as well as Lulu (2016). Saringe (2011) observed that mobility remains the most important pastoralists' adaptation to spatial and temporal variations in rainfall, and during drought years. Martin (2012) also observed that pastoral season mobility is one of the best adapted and useful means of obtaining what livestock need in an ever-variable environment.

Since pastoralism is adapted to variable forage supplies and water distribution, the ability of pastoralists to survive in these marginal lands is attributed to their opportunistic mobility and diversified livestock husbandry. Rainfall unpredictability, both in space and time causes uneven and unpredictable levels of productivity. Also according to Meena *et al.,* (2006), pastoral seasonal mobility has proven to be the best form of land use of highly variable and heterogeneous pastoral lands in the arid and semi-arid regions as well as in the mountainous regions due to the fact that it enables the livestock to graze the

diffuse and scattered vegetation of the regions rangelands or take refuge to more favorable sites during drought. However, despite of mobility being the most practiced among agro-pastoral communities (Maasai) still there is a need to design better way of seasonal mobility especially planning special areas for animal keeping with specified animal routes as well to review current multi-sectoral policies and laws(see Plates 1and 2).

Plate 1: Grazing goats in thickets and Cattle movement to distant areas searching for water

Plate 2: Cattle Movements to Distant areas searching pastures and a Maasai grazing cattle in semi-arid areas

Source: Authors 2017

The use of Traditional by-laws for Pastures Conservation/rotational use

The establishment and enactment of traditional by-laws for pastures conservation in Maasailand that regulate livestock grazing was revealed by household respondents as one of resilience and adaptive system that has been

used by pastoralists against the impacts of climate change and variability. It was noted that pastoralists had traditional knowledge on how to preserve their pasture/forage for reducing forage shortage during pasture stress times especially during the dry seasons in almost all study villages.

Examples of these by-laws are those related to pasture conservation and water conservation. As for pastures, grazing areas are divided into restricted and non-restricted zones **(*lopolol*).** In each zone there are by laws guarding the utilization of each zone. Defaulters of the by-laws are normally fined Tshs 200,000 when one grazes animals to restricted pastures for dry seasons. Regarding water conservation, constructions of traditional dams (e.g. sand dams) are common in the study area which especially was observed in Saunyi, Ndedo, Makame and Erelai villages. In the study area, some local excavated dams are restricted to use until the dry season (*Serenge*) and others are not restricted and these are used during the rainy season. Defaulters are normally fined. Mahonge *et al.,* (2014) showed that some strategies e.g. excavation of small dams are the initiatives of the pastoralists themselves based on their long-term interaction and experience with the environment. These are meant to avoid walking long distances in search of water. Therefore, despite of having modern day by-laws, the agro-pastoralist have their own designed innovative adaptation structures which has been existing from time immemorial, and should be integrated with modern ones to increase environmental sustainability as indicated in Plates 3-4

Plate 3: Young Conserved pastures for calves and **Matured pastures for livestock in dry season**

Plate 4: Pastures conserved for livestock and Conserved pastures for goats
Source: Authors 2017

Traditional water points construction

During this study, it was revealed that the constructed wells (Njoro), varying in size and depths, were used only by the agro-pastoral community members in all study villages. For outsiders, they must ask permission from the village leaders who will provide permission. However these wells mostly are under particular clan, hence sometimes one to get water needs permission from the clan which constructed such wells. It was revealed that most of the villages have wells which differ in terms of size and depth. Wells are ways of ensuring a year round supply of water for the community domestic use and livestock. Water reservoirs/wells have been one of the strategies to adapt water availability problems especially during the dry seasons. Makame village has more than 45 constructed wells under different clans (see Plates 5-6).

Plate 5: A deep well for fetching water and another deep well for fetching water


Plate 6: Livestock and donkeys drinking in well/Njoro and Constructed drinking place for livestock
Source: Authors 2017

Reducing stock number by selling during the dry season to buy food

Food insecurity has been one of the push factors for most of agro-pastoral communities in study villages to sell their livestock especially during the dry seasons as it was mostly observed in Makame and Saunyi villages. About 60% of respondents mentioned reducing livestock numbers to be an alternative way especially during dry season. However, pastoralist in Tanzania have been reluctant to reduce the number of their livestock until the dry season whereby the prices of cattle fall down due to poor health as a result of poor pastures and water shortage. According to District Livestock and Fisheries Officer of Kilindi district drought which hit the district in 2009, 2014 and 2016 caused prices of cattle to be very low ranging from Tsh. 80,000-120,000/- per cattle. However, the reduction in livestock numbers requires alternative sources of food for agro-pastoralist in Tanzania, and thus may lead to changes in national food policy and laws.

Maasai women transporting water with donkeys from innovated traditional water points for domestic use

Water resources availability for domestic use in the study villages has been a problem and it is influenced by various factors, including climate change and variability through droughts and other livelihood activities. Various research findings show that it is in the intermediate region receiving between 400 to 1000 mm of rain per year that the impact of climate change and variability on surface drainage will be greatest as highlighted by Mary and Majule (2009) and FAO (2007). Agro-pastoral districts such as Kilindi, Monduli, Kiteto, Simanjiro and Ngorongoro receive below 700 mm of rainfall. The impact is felt non-linearly and drier areas within this range experiences significantly greater loss in surface drainage with a decrease in rainfall than wetter areas. Experience have shown

that communities in Kiteto and other rangeland areas are experiencing a decline in ground water level due to drying of water in wells, river streams that used to give water throughout the year. The drying has affected both people and livestock including wild animals.

Agro-pastoral women move very long distances with donkeys fetching water in constructed wells where they use more than 6 hours. According to Village Executive Officer of Ndedo village (40 years old) said that most of nearby wells which were used previously now does not exist due to prolonged dry land. Modern wells are needed in these communities especially in this era of global environmental change which will reduces distance for fetching water which affects Maasai women (see Plates 7-8)

Plate 7: Donkeys for fetching water and another group of donkeys for fetching water

Plate 8: Water cans for fetching water and a group of donkeys ready for fetching water

Source: Authors 2017

Traditional Maasai constructed water reservoirs for livestock (Mboutu)

The influence of water on livestock productivity within rangelands for grazing has been reported to be of paramount importance. The volume of water in natural sources nowadays goes down due to prolonged droughts affecting livestock and crop farming. Therefore, because of persisting droughts which has resulted shortage of water, agro-pastoralists through their own indigenous knowledge systems (IKS) have developed their own new water reservoirs for their livestock adaptation practices locally known as **Mboutu.** Mboutu has been serving pastoralist for a very long time especially during the dry season when water becomes a very scarce resources in semi-arid areas. Previously, Mboutu were built with natural vegetation/small sticks with the help of mud, then pouring water from water points to Mboutu where livestock used to drink. However, due to increased environmental change because of the current climate change and variability, pastoralist have been required to improve much their traditional knowledge system as to go with the prevailing environment as the old water reservoir's (Mboutu) currently are not effective and efficient and so allows water loss; also increased human and livestock population as well as recurrent droughts makes this system to be less efficient. Therefore they have improved much this water reservoirs (Mboutu) whereby nowadays are built using concrete and cement preventing water loss (see Plate 9-10).

Plate 9: The old water reserves (Mbotu) at Makame Village

Plate 10: Old water reservoir and pipe for watering cattle at Ndendo Village
Source: Author 2017

The old Mboutu have been abandoned nowadays due to loss of water, and inability to serve large numbers of livestock, hence the agro-pastoralist have innovated the new/modern Mboutu using improved building materials like cement and concrete (see Plates 11-13).

Plate 11: Modern water reserves in Makame Village

Plate 12: Modern cattle watering points in Ndendo Village

Plate 13: Goats drinking water in a modern water point at Ngapapa Village
Source: Authors 2017

Conclusion

Kiteto and Kilindi districts currently are highly dominated by pure pastoral Maasai communities than agro-pastoral as most of them have changed from growing crops due to persistent droughts. Hence they have been experiencing climate change and variability impacts for nearly five decades now. Drought stress is a major challenge in study districts and it has negatively affected grazing resources and pastoralists livelihoods in various ways such as drying of

water points (Njoro), drying of livestock pastures, emergency of new livestock diseases, and increased livestock mobility as to escape from droughts and searching water and pastures.

Therefore, impacts of climate change and variability are real and negatively affects livestock production which results to frequent food insecurity hence innovated adaptation strategies have been serving them or working well, but not effectively and efficiently as indigenous knowledge system (IKS). Nonetheless, what is missing in these communities is the integration of scientific knowledge in adaptation to harsh environment which have intensified food insecurity. However, the study noted that, some of the implemented strategies are not sustainable as they depend on the economic status of the household head or family, hence the study recommend best adaptation practices they need much building capacity on diversification of their sources of livelihoods like engaging with crop growing through droughts resistant crops as well as integrating scientific ways of adaptation strategies. Also, integrate multi-sectoral through interventions that target agro-pastoralists' resilience and adaptation by integrating meteorological organs, academic research and other developmental activities through civil society and community based organizations could be the most important pathway for resilience and adaptation to climate change impacts in semi-arid rangelands.

REFERENCES

Agrawala, S., A. Moehner, A. Hemp, Maarten van Aalst, S. Hitz, J. Smith, H. Meena, S.M. Mwakifwamba, T. Hyera and O.U. Mwaipopo (2003). Development and Climate Change in Tanzania: Focus on Mount Kilimanjaro. Paris: OECD

Food and Agriculture Organization (FAO) (2007) Adaptation to climate change in Agriculture, forestry and fisheries: Perspective, framework and priorities, Interdepartmental working group on climate change, Rome, Italy.

Intergovernmental Panel on Climate Change (IPCC) (2001), Climate Change 2001: *Adaptation Vulnerability*, Cambridge university press.

Intergovernmental Panel on Climate Change (IPCC) (2007b), *Climate Change Impacts, Adaptation and Vulnerability, Contribution* Working Group II to the fourth Assessment Report of IPCC, Cambridge University Press. Cambridge.

Intergovernmental Panel on Climate Change (IPCC) WGII (2007) Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Summary for Policymakers.

Intergovernmental Panel on Climate Change, (IPCC). 2001. Climate Change Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the third Assessment Report of IPCC, Cambridge University Press, Cambridge.

Kangalawe, R, Lyimo, J. (2013). Climate Change, Adaptive Strategies and Rural Livelihoods in Semiarid Tanzania. *Natural Resources*, 4: 266-278

Kilindi District Profile (2017), *Kilindi District Council Documentaries*, Longido Arusha, Tanzania. Internal Report, 2015

Kiteto District Profile (2017), *Kiteto District Council Documentaries*, Longido Arusha, Tanzania. Internal Report, 2015

Lulu E (2016) Female Migration and Control Over Resources in Tanzania: A Case of Parakuyo Maasai Women in Coast Region, *Journal of the geographical Association of Tanzania*, Vol. 37 pp. 126-151)

Livestock Research for Rural Development. Volume 26, Article #227. Retrieved May 22, 2015.

Liwenga E.T. (2003), Food Insecurity and Coping Strategies in Semiarid Areas: The Case of Mvumi in Central Tanzania, The Department of Human Geography, Stockholm University, Stockholm.

Mahonge, C., Mwilawa, A., Ngendello, M. and Mtambuki, A.(2014). *Policies Issues for Enhancing Pastoralists' Resilience to Climate Variability Versus Reality in Longido District Tanzania.*

Martin, C. (2012). *The Impact of Climate Variability on Livelihood of Pastoral Communities in Longido District, Arusha Region*, MA Dissertation, Dar es Salaam, University of Dar es Salaam.

Mary AL, Majule AE, 2009. Impacts of climate change, variability and adaptation strategies on agriculture in semi-arid areas of Tanzania:

Meena, H. E., Lugenja, M. and Stephenson, M. (2006).*Climate Change Impacts on Livelihood in Tanzania and Adaptation Options; Experience of Floods and Drought in Rufiji*, Dar es Salaam, CEEST foundation.

Msangi, A. (2014). Community and Government: Planning together for climate resilient growth: Issues and opportunities for building better adaptive capacity in Longido, Monduli and Ngorongoro Districts, northern Tanzania. IIED, London

Mubaya, C. P. (2010). *Farmer Strategies towards Climate Variability and Change in Zimbabwe and Zambia,* PhD Thesis submitted to the University of the Free State. Unpublished Thesis.

Mwandosya. M. J., Nyenzi B. S., and Luhanga. M. L. 1998. *The Assessment of Vulnerability and Adaptation to Climate Change Impacts in Tanzania*. Dar es Salaam. Centre for Energy, Environment, Science and Technology (CEEST).

NAPA (2006), *National Adaptation Programme of Action*, United Republic of Tanzania, Vice president, Division of Environment, Dar es salaam.

Sangeda A Z and Malole J L, (2014) Tanzanian rangelands in a changing climate: Impacts, adaptations and mitigation.Net *Journal of Agricultural Science* 2(1) 1-10 www.netjournals.org/pdf/NJAS/2014/1/13-045.pdf

Sangeda A Z, Maleko D and Mtengeti E J,(2013) Socio-economic and ecological dimensions of climate variability and change for agro-pastoral communities in central Tanzania.*Livestock Research for Rural Development. Volume 25, Article #209*

Sangeda A. Z. and Malole J. L. (2013) Tanzanian rangelands in a changing climate: Impacts, adaptations and mitigation. Department of Animal Science and Production, Sokoine University of Agriculture, Morogoro, Tanzania

Saringe, E. (2011). *Impact of Climate Change to Pastoralist and Hunter-Gatherer communities of Tanzania:* A Case study of Kiteto and Simanjiro Districts, PINGO's FORUM, Unpublished Work.The case of Manyoni District in Singida Region, Tanzania. Afr J Environ Sci Technol, 3(8):206-218

Shemsanga C., Omambia A.N and Gu, Y. (2010). The cost of climate change in Tanzania: Impacts and adaptations; Journal of America Science, 6(3), 182-196,hht://www.americascience.org,retrived on 13th march 2018.

Tanzania Climate Action Report (TCAR) 2015 Irish Aid https://www.irishaid.ie/media/irishaidpublications/TZA-Country-Climate-Action-Reports-Tanzania-2015.pdf

Thornton, P.K., J. van de Steeg, A. Notenbaert, and M. Herrero, 2009b: The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agricultural Systems, 101(3), 113-127

United Republic of Tanzania (URT). 2011 "The Economics of Climate Change in the United Republic of Tanzania." Development Partners Group. http://www.economics-of-ccin-tanzania.org/image/Final_report_launch_vs_3.pdf (Date accessed 26Th May 2018).

World Bank (2006) World development indicators. Washington D.C.

Yanda, P. Z. and Mubaya, C. P. (2011).*Managing a changing climate in Africa*: *Local level vulnerabilities and adaptation experiences*, Mkuki na Nyota Publishers Limited, Dar es salaam.

Tran, M (2011). Investment in pastoralists could help combat East Africa food crisis. The Guardian, 2 Sept. 2011.

Rötter, R., & van de Geijn, S. C. (1999).Climate change effects on plant growth, crop yield and livestock.*Climatic Change, 43*(4), 651–681. doi: 10.1023/A:1005541132734

West, J. W. (2003). Effects of heat-stress on production in dairy cattle.*Journal of Dairy Science, 86,* 2131–2144

White, N., Sutherst, R. W., Hall, N., & Whish-Wilson, P. (2003).The vulnerability of the Australian beef industry to impacts of the cattle tick (Boophilus microplus) under climate change.*Climatic Change, 61,* 157–190.

Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural Systems, 101,* 113–127. doi: 10.1016/j.agsy.(Date Acesssed 5th May 2015)

Thornton, P.K., J. van de Steeg, A. Notenbaert, and M. Herrero, 2009b: The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agricultural Systems, 101(3), 113-127.

Solomon, T.B., H.A. Snyman, and G.N. Smit, 2007: Cattle-rangeland management practices and perceptions of pastoralists towards rangeland degradation in the Borana zone of southern Ethiopia. Journal of Environmental Management**, 82(4),** 481-494.

Mwakaje, A (2013).The impact of climate change and variability on agro-pastoralists'economy in Tanzania, Environmental Economics, Volume 4, Issue 1, 2013

Hulme M, Doherty RM, Ngara T, New MG, Lister D(2001). *African climate change: 1900-2100. Climate Research., 17:145-168.*Kangalawe, R. Y. M., Liwenga, E .T. (2005). Livelihoods in the wetlands of Kilombero Valley in Tanzania: Opportunities and Challenges to Integrated Water Resource management. *Physics and Chemistry of the Earth* 30: 968 – 975.

Deressa, T., Hassan, R., Alemu, T., Yesuf, M. and Ringler, C. *(2009). Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798.*

Msangi, S. and Rosegrant, M. W. (2012). Feeding the Future's Changing Diets: Implications for Agriculture Markets, Nutrition, and Policy. In: *Reshaping Agriculture for Nutrition and Health*. (Edited by Shenggen, F. and Rajul, P.), International Food Policy Research Institute, Washington DC. pp. 65 – 71.