Perceptions of Tanzanian Livestock Dependent Communities on Climate Related Changes: A Case of the Maasai Pastoralists in Longido District, Northern Tanzania

Salanga, R.J. and M.I. Muhanga

Department of Development and Strategic Studies, College of Social Sciences and Humanities, Sokoine University of Agriculture, P.O. Box 3024, Morogoro, Tanzania

*****Corresponding author e-mail: *salanga@sua.ac.tz*

Abstract

The study was carried out in Longido District, northern Tanzania to understand the Maasai pastoralists' perceptions and interpretations of changes in climate and variability and determine their livelihood coping strategies with climate variability and change following a devastating drought in 2009/2010. Primary and secondary data were collected using household questionnaires, key informant interviews, and focus group discussions. The perception of climate change and variability was supported with a time-series analysis of rainfall and temperature data. The results show that the Maasai pastoralists are aware of the current variations and changes in climate, which they admit to have become increasingly difficult to predict using their traditional knowledge. Furthermore, the study identified indicators of climate change and variability and the associated adversities as perceived by the Maasai pastoralists in the study area. The statistical analysis of 30 years of climatic data produced results that are in agreement with the Maasai pastoralists' perception of climate change and variability. It is imperative to understand people's perceptions and their responses to climate-related impacts in the future. Since some of the pastoralists' ways to cope with climate-related adversities are failing, new means or techniques have certainly emerged. It is recommended that the present techniques in designing alternative adaptive strategies for pastoralism should be examined and up-scaled, which is the most productive form of land use for a patchy and scattered range of land resources.

Keywords: Climate change and variability, Interpretation, Maasai Pastoralists, Perception

Introduction

Humanity is intertwined with nature for its existence. This is especially true for pastoralists who depend on land for key resources to sustain pastoralism. The Maasai are dependent upon access to communal land and other natural resources for their livelihood through livestock keeping (Homewood *et al.,* 2011; Ayantunde *et al.,* 2014). As a result of this reliance, pastoralists are especially vulnerable to changes caused by climate change and variability because their economic, social and cultural values are closely linked to the natural environment and climate. A case in point is Longido District in the northern parts of Tanzania, which has been experiencing recurrent severe and prolonged dry spells. These climate-related changes have resulted into serious consequences for the dryland ecosystems and to the pastoralists and agro-pastoralists who are the main inhabitants of the rangelands in the district. For instance, the severe drought of 2005-2006 caused loss of large numbers of livestock and devastated pastoralist communities in the area. Furthermore, in 2008-2009, devastating drought re-occurred, which rocked the area, further entrenching the poverty already pervasive in the pastoral communities and contributing to widespread hunger. The drought reached deadly proportions, killing nearly 700,000 cattle in Arusha Region. Mass deaths of livestock occurred in several villages in Longido District as drought scorched the vegetation, leading to the need for immediate external support (WVP, 2010; Njau *et al.,* 2014).

While the impacts of climate change and

variability to various communities around the world are increasingly evident (IPCC, 2007), there is limited understanding of the perceptions and interpretations of climatic-related changes among different communities due to their differences in terms of vulnerability and adaptive capacities to climate related impacts and adversities. This understanding is crucial in determining responses in dealing with climate related adversities. Thus, the study intended to fill this knowledge gap based on experiences from the Maasai communities dwelling in Longido District, in northern Tanzania. The Maasai are among the few remaining pastoral communities known for their entire dependence on the natural surroundings for survival. They are dryland dwellers who are endowed with rich indigenous or ecological knowledge about the environment in which they live and interact with. Their long time interaction with nature has enabled them to observe behavioural activities of organisms and encoded some useful skills/ meanings for use in their culture. Furthermore, this experience has taught them to understand weather variations, thereby developing coping mechanisms and adaptive responses to climate change that are seen among the Maasai pastoralists. Thus, if this sort of encrypted cultural meanings could be decoded using our conventional science, a lot more could be learnt about the coping mechanisms and adaptive capacity of the Maasai pastoralists in the realm of adversities brought about by changing climate and variability.

The critical questions that the study intended to answer were how do the Maasai pastoralists in the study area perceive and interpret climatic variability and change, and what are the indigenous livelihood strategies deployed by the pastoralists in the study areas to cope with climate change and variability? Thus, this paper explores the Maasai pastoral communities' perception and interpretation of climate change and variability.

Materials and Methods

Description of the Study Area

Longido District is one of the seven districts of Arusha Region. It is bordered by Meru and Rombo Districts to the east, Ngorongoro District to the west, Monduli and Arusha Districts to the south and Siha District to the south-east. To the north lies the Republic of Kenya (Fig. 1). The district has an area of 7,782.01 km^2 of which 6,392.35km^2 (82.14%) is grazing land/game area; 1,023.90 km2 (13.6%) is arable land and 365.78 km^2 (4.7%) is under forest reserve (URT, 2014). Furthermore, 26.79% (292.23km^2) of the arable land is under cultivation (Odgaard and Maganga, 2013).

Climatically, Longido District is recorded as one of the driest areas in Tanzania; the temperature ranges from 20°C – 35°C. Rainfall ranges from less than 500 mm in lowlands to 900 mm in higher altitudes. From the year 2007, the district experienced prolonged dry seasons. The rainfall increased?from 500 mm to 900 mm, 79.3 mm to 179 mm. Short rains normally start in October and end in December, while long rains start in February and end in May.

Topographically, the District comprises both low and high-elevation areas ranging from 600 m to 2,900 m above sea level. In addition, there are several isolated mountains that are found in the District. These include Ketumbeine, Gelai, Oldonyo Lengai and Longido Mountains. The vegetation found is mixed bushlands, grasslands and forest. According to the 2012 National Census, the population in Longido District was 123,153 of which males were 60,199 and 62,954 were females. The average household size is 4.5 (URT, Census Report, 2013). The main economic activities are livestock rearing and wildlife tourism, with more than 90 per cent of the population engaged in livestock keeping (Odgaard and Maganga, 2013).

Study Population and Sampling

A socio-economic survey was conducted in the study area to assess the pastoral community's perception and interpretation of climate change and variability and implications for their livelihoods and way of life as well as their coping strategies. The fundamental reasons for the choice of the study area are: first it represents typical dryland areas of Tanzania whose dwellers are predominantly pastoral communities. Longido is home to the Maasai who practise nomadic and transhumance pastoralism, with a few residents who are sedentary and practise

agro-pastoralism. Secondly, Longido District was hardest hit by recurrent climate-related adversity (drought) in 2005-2006 and from late 2008 to early 2010, during which time the Maasai pastoralists suffered massive losses of their livestock. The District is described as one of the "drought-prone" areas in Tanzania (URT, 2006).

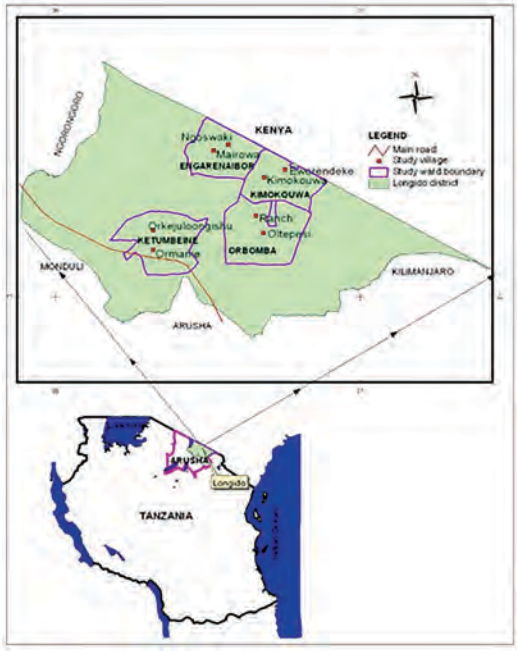

Figure 1: Map of the study area-Longido District showing Wards and Villages

A multi-stage sampling technique was used to select geographical localities within the district from which pastoral households were obtained. The first stage involved a purposive selection of three divisions out of 4 in the district whose dwellers are typical Maasai pastoralists, followed by a random selection of four representative wards from each division out of the available 32 wards. These divisions were selected on the basis of their inhabitants being typical Maasai pastoralists whose occupation is mainly transhumance pastoralism as opposed to other divisions which are mainly dominated by agro-pastoralists and other non-pastoralist ethnic inhabitants. This was followed by the selection of two representative villages from each ward. Thus, from four wards a total of 8 villages were selected using simple random sampling, followed by random sampling of respondents.

The sampling frame of this study was pastoralist households registered in the villages. Village register books containing the names of all households were used for sampling. A sample of 335 respondents was randomly drawn from the population in the selected villages within the district and to whom a semi-structured questionnaire was administered. This sample size represented an average of 42 respondents selected from each village. According to Bailey (1994), a minimum sample size of 30 is normally sufficient for studies in which statistical data analysis is to be done. Statisticians have also shown that, the larger the sample, the greater the accuracy (Kothari, 2005). Thus, a sample size of 30 or more will usually result in a sampling distribution that is very close to the normal distribution, and the larger the absolute size of a sample, the closer its distribution will be to the normal distribution (Stutely, 2003; Saunders *et al.,* 2007; Saunders *et al.,* 2009;). In view of this, a sample size of 335 respondents was considered adequate for statistical analyses. In addition, four key informants and six to eight Focus Group discussants were purposively selected from each village. Such key informants were people (mainly renowned elders i.e. Oloiboni/Iloibonok) who had both sufficient historical knowledge about the area and quite familiar with climate change and variability patterns of the area over time. This category also included village leaders such as Village Chairpersons, Village and Ward Executive Officers, and Agricultural and Livestock Extension Officers in each village making a total of 32 key informants. All these were interviewed using interview guide. On the other hand, focus group discussions involving about 6-8 members represented the elderly (men alone), females and youths. A checklist of formulated questions was used to guide the focus group discussions.

In this context, a household is the basic unit of decision making for production and consumption; hence it was used as a unit of analysis preferably with the heads of the households as respondents. Information collected from households included perceptions

about climate change and its interpretation by the Maasai pastoralists, climate change impacts on their livestock, livelihood options and other existing adaptive strategies to impact of climate change and variability. The results from this study are complemented with time-series analysis of rainfall and temperature data for 30 years from the meteorological station within the study area.

Data collection, processing and analysis

Data were obtained from primary (field observations and interviews of household heads, focus group discussions and meteorological data) and secondary sources (government documents or reports). Data from household surveys were analyzed by means of descriptive and inferential statistical methods. Measures of the central tendency of key variables were computed to analyse the socio-economic characteristics of pastoralists and their practices or responses to climate change and variability. Important trends for climatic data were generated using Instant Statistical Software -The Mann-Kendall test and Sen's slope estimates - the Excel template application (MAKESENS) analysis. Important data patterns generated were tested for significance.

Perception and attitude were measured using a matrix of rating questions. The study employed a Likert rating scale to measure the perception of climate-related changes among pastoralists in which a respondent was asked how strongly she or he agreed or disagreed with a series of statements. Several questions on climate change and variability (as perceived by respondents) were prepared for respondents to answer based on their level of agreement or decision-making, thus a five-point Likert scale was developed for use. For this case, each adaptive strategy was determined through FGDs. During FGDs, discussants expressed their perceptions and described changes in climate as being "good", "bad", "Very bad", "Unchanged/normal", "Increased/decreased" and some were indifferent.

This study obtained data on the Maasai's views on the current climate change and variability and also 30 years of meteorological data for rainfall and temperature from Longido District. However, the Tanzania meteorological stations located in Longido have not been operational for almost two decades. As a result of this limitation, the actual rainfall and temperature records for Longido are non-existent. Thus, because of this limitation, the study opted for a historical analysis of 30 years of both rainfalls and temperatures meteorological data obtained from nearby weather stations located in Arusha, which is about 70 Kilometers from Longido. Consultation with the TMA on the use of Arusha meteorological data set for Longido was justified due to the non-existence of such data sets within Longido District itself. Furthermore, TMA advises that, since it is all flat terrain and there are no topographic barriers such as mountains and forests between Arusha meteorological station and Longido, then climatic data for Arusha meteorological station can be used to describe climatic changes and variability for Longido District. Thus, in this case, the limitation and the assumptions justify the use of Arusha data set to describe and analyse climatic changes and variations in the study area.

Results

Perception and interpretation of climatic-related changes by the Maasai pastoralists

Results from households survey conducted from 8 villages in Longido District show a clear Maasai pastoralists perception that there are significant changes in the trends of temperature and rainfall in their respective villages.

The study revealed that the popular and common phrases "climate change and climate variability" were not commonly used among the Maasai communities. This explains why during the FGDs the majority of the Maasai pastoralists had a positive perception of climate change and variability. The results presented in Table 1 show that, in some villages, there was a general perception that the climatic condition was good by 30.1% in Ranchi, and Eworendeke (26.1%) villages or unchanged in Eworendeke (25%), Ngoswaky (25%) and Mairowa (18%) villages with a significant Chi-square value of 73.71, which was significant at the 0.001 level. This shows that there are indeed variations in perceptions of climatic-related changes among

Table 1: Perception and interpretation of climatic-related changes among the Maasai pastoralists (N=335)

Variable	Responses	Villages								Pearson Chi-square Coefficients	Sig. (P value)
		Ranchi (n=44)	Oltepesi (n=37)	Eworendeke (n=45)	Armanie (n=42)	Orkejuloongishu (n=45)	Ngoswak (n=40)	Mairowa (n=40)	Kimokouwa (n=42)		
Perception of climate	Good	30.4	4.3	26.1	13.0	8.7	8.7	8.7	.0	73.71	.000
	Bad	16.6	9.	10.1	19.6	14.1	12.1	8.5	9.5		
	Very bad	2.1	15.5	15.5	.0	14.4	10.3	18.6	23.7		
	Unchanged	12.5	12.5	25.0	.0	6.2	25.0	18.8	.0		
Perception on rainfall	Increased	5.6	5.6	11.1	5.6	11.1	5.6	50.0	5.6	13.10	.000
	Decreased	14.7	15.2	7.8	17.2	14.2	7.8	10.8	12.3		
	Change in timing of rains	12.3	3.5	35.1	10.5	3.5	8.8	5.3	21.1		
	Not changed	19.2	.0	.0	.0	7.7	34.6	23.1	15.4		
	Do not know	3.3	10.0	23.3	.0	33.3	30.0	.0	.0		
Perception on temperature	Increased	15.2	9.7	9.7	14.8	15.2	12.1	13.2	10.1	59.27	.001
	Decreased	7.4	11.1	37.0	3.7	7.	11.1	.0	22.2		
	More/or less extreme	6.2	18.8	37.	6.2	.0	12.5	6.2	12.5		
	Unchanged	7.7	23.1	15.4	7.7	.0	30.8	.0	15.4		
	Do not know	4.5	13.6	9.1	4.5	18.2	.0	22.7	27.3		
Perception on winds	Increased	12.1	10.1	16.1	13.3	8.9	13.3	13.3	12.9	78.78	.000
	Decreased	20.0	8.0	4.0	4.0	16.0	8.0	8.0	32.0		
	More/or less extreme	8.0	20.0	12.0	28.0	12.0	12.0	.0	8.0		
	Unchanged	.0	.0	.0	9.1	63.6	9.	18.2	.0		
	Do not know	26.9	19.2	3.8	.0	34.6	3.8	3.8	7.7		
Perception on frequency of droughts	Increased	15.9	9.5	13.9	12.3	12.7	11.5	12.3	11.9	36.33	.020
	Decreased	6.1	18.2	9.1	27.3	6.1	6.1	15.2	12.1		
	Constant	8.3	25.0	8.3	8.3	.0	25.0	16.7	8.3		
	Unsure	2.6	10.5	15.8	2.6	28.9	15.8	5.3	18.4		
Perception on frequency of drying rivers	Increased	14.3	7.0	13.1	10.7	15.1	14.3	11.1	13.5	64.54	.000
	Decreased	18.2	4.5	9.1	4.5	27.3	9.1	18.2	9.1		
	Constant	25.0	.0	16.7	8.3	8.3	.0	33.3	8.3		
	Unsure	2.0	32.7	16.3	26.5	.0	4.1	8.2	10.2		
Perception on occurrence of livestock diseases	Increased	15.6	13.8	14.4	11.9	13.8	11.2	11.2	8.1	58.93	.000
	Decreased	10.2	11.8	6.3	17.3	9.4	14.2	12.6	18.1		
	Constant	31.6	.0	31.6	.0	31.6	5.3	.0	.0		
	Unsure	.0	.0	27.6	3.4	17.2	10.3	20.7	20.7		
Perception on hunger	Increased	14.	8.6	15.6	12.3	13.5	11.9	11.5	11.9	54.70	.000
	Decreased	8.3	12.5	8.3	4.2	16.7	8.3	33.3	8.3		
	Constant	7.1	39.3	3.6	3.6	10.7	7.1	3.6	25.0		
	Unsure	10.3	5.1	10.3	25.6	12.8	17.9	7.7	10.3		
Perception on changes on vegetation today than was in the past	Agree	15.9	10.6	11.4	14.4	13.6	8.3	17.4	8.3	37.11	0.116
	Uncertain	.0	9.1	45.5	18.2	.0	9.1	.0	18.2		
	Disagree	.0	6.7	13.3	20.0	26.7	26.7	.0	6.7		
	Strongly disagree	12.5	25.0	12.5	.0	12.5	12.5	12.5	12.5		

the Maasai pastoralists. However, when asked about their opinions on the current observations about rainfall, temperature, winds, frequency of droughts, drying up of water sources or bodies, frequency of occurrence of livestock diseases, food insecurity and changes in vegetation and landscapes they to narrate depicting their great awareness on environmental changes and adversities as a result of climate change and variability. Table 1 presents the pastoralists' perceived indicators of climate variability.

Either, perception was also tested inferentially using Chi-square test. The respondents in the study area showed statistically significant differences in their perceptions and interpretation regarding climate-related changes among the pastoralists in the study area, $\chi 2$ (1, n = 335) = 54.46. This shows that there are indeed variations in perceptions and interpretations of climatic-related changes among the Maasai pastoralists.

During key informant interviews and FGDs, discussants described changes in climate as being "good", "bad", "very bad", "unchanged/ normal", "increased/decreased" and some were indifferent. However, the overall perception from the FGDs in terms of climate change was bad as there were more negative impacts related to climate change and variability. In this case, perceived "good" weather was associated with enough timely and non-erratic rainfall accompanied by adequate grass and herbs for livestock, resulting in high milk production, very few incidences of pests and animal diseases, plenty of water for livestock to drink within the grazing areas and with less or no mobility throughout the year. Whereas the perceived "bad" climate was associated with unreliable rainfalls culminating in drought, recurrent incidences of pests and livestock diseases, inadequate river flows, strong winds, poor milk production, and poor animal health resulting in food insecurity throughout the year. On the other hand, perceived "very bad" changes in climate were connected with very low or no rainfall at all, resulting in severe scarcity of water for both humans and livestock as a result of drying water points and rivers, prolonged drought, emaciation of livestock, shortage of milk and milk products, extreme temperatures, acute shortage of grasses followed by death of animals, high incidences of pests and diseases, characterized by high mobility in search of water and grasses throughout the year (Table1). Based on this perceived description, the results indicate elements of climate (such as, temperature, and winds) were perceived to have increased noticeably across all the seven villages except Ranchi Village. Crosstabs of all eight villages (i.e. Ranchi, Oltepesi, Eworendeke, Armanie, Orkejuloongishu, Ngoswki, Mirowa and Kimkouwa) indicated similar results at $p<0.001$. The Maaasi pastoralists at Ranchi Village felt that the wind has decreased because the village is somehow located in the rift valley. Across all the villages, rainfall was felt to have decreased and there were changes in timings except at Mairowa Village where many respondents felt that rainfall has increased. The majority of pastoralists still holding bad memories of the year 2009 when they were hard hit by a devastating drought, hence felt the situation had not improved yet. The Maasai pastoralists in Longido District are still experiencing frequent recurrence of prolonged droughts, incidences of pests and livestock diseases, increased temperatures, decreased and or erratic rainfalls and strong winds. This is supported by the following quotation:

"This situation has rendered it difficult to practise pastoralism. Animals have become thin and weak thus unfit for trekking, yielding very little milk and fetching very low prices in the markets. We don't know where to take our herds because we are quite aware that even those places where we used to relocate with our animals are also dry with no adequate water and pastures to feed our animals" (Oloiboni-a renowned elder, in Orbomba Ward).

For instance, the bad weather was associated with outbreaks of pests and animal diseases, frequency of droughts, drying of rivers, the occurrence of famine and changes in vegetation composition ($p \leq 0.001$) resulting into massive losses of livestock, creating an immediate need for restocking to sustain the Maasai livelihoods as depicted in the narration of one of the FGD participants:

"We are no longer sure of when the rains start and when they stop. We are experiencing

too much heat and very little rainfall. There are a lot of challenges to life, especially the availability of food for us, pastures and water for our livestock. Indeed, there is no assurance of food due to climate change hazards. The drought affected people in this area in 2008/2009 and a lot of them lost their herds, and the government, through the President, had to re-stock" (Key informant, Longido Village)

(Irmaat) and some species of frogs, depicted – from scientific indicators of climate variability and change a decreasing trend of rainfall and its unpredictability, shifting rainfall patterns and increased frequencies of drought (Table 2).

Thus, the Maasai's traditional indicators of climate variability require long time experience to understand. In this case, the Maasai elders are the custodians of this knowledge and hence are

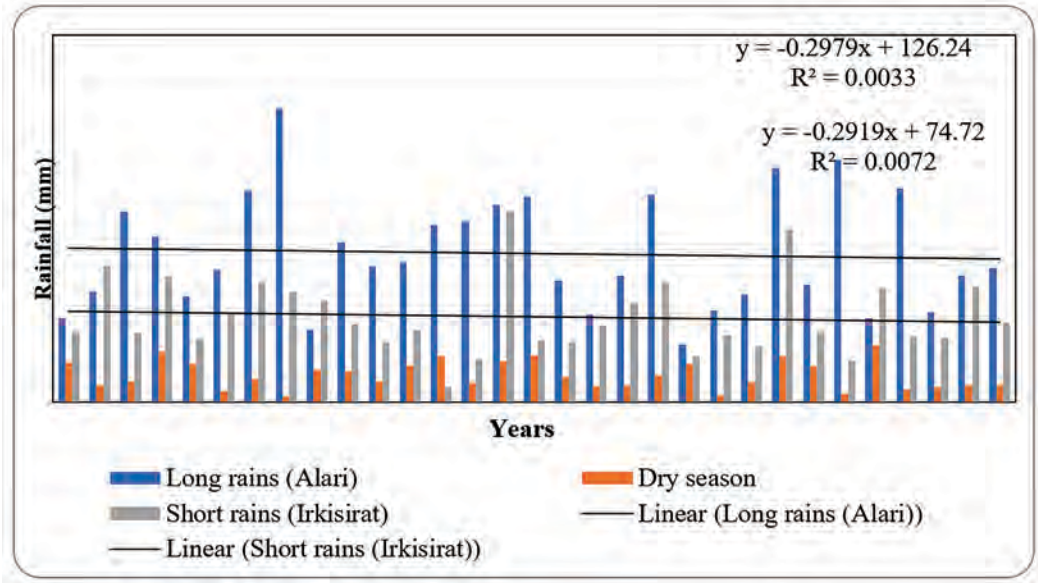

Figure 2: Seasonal rainfall Irkisirat and Alari for Longido District

It was revealed in this study that the Maasai pastoralists have their traditional ways of forecasting weather and climate-related changes or events using behavioural changes or patterns observed in some species of insects, animals, plants and birds. The observed behaviours or some unique changes occurring in these organisms were considered key traditional indicators for determining or forecasting changes in climate and variability locally. Other indicators include the appearance or disappearance of certain plant species and insects and the appearance of some stars. These indicators and their respective interpretations were noted to be similar to the scientific indicators of climate change and variability (Table 2). For instance, the appearance of certain insects, the behaviour of some animals, and the movement of birds i.e. Kigong'oto / Ordilo, Ostrich Armyworms (Enkurto), locusts

ones who can decode or unpack the encrypted cultural and climate-related meanings in their culture. Thus, in their own traditional way, the Maasai communities expressed their awareness on changes in climate variability across all the eight villages. The results in Table 2 represent the Maasai pastoralists' perceptions of climate change and variability and their respective indicators which they use to determine or foresee the changes in climate variability. Furthermore, the Maasai were able to identify adversities related to climate change and variability. The perceived changes in climate change and variability among the Maasai pastoralists include decreased rainfall trends, unpredictability and shifted patterns, increased temperatures, increased frequencies of droughts/recurrent droughts resulting in a severe shortage of grasses and water for livestock, a severe shortage of milk, culminating into food insecurity extreme

Table 2: The Maasai Pastoralists' Perception and traditional indicators of climate change and variability

Scientific indicators of climate change and variability	The Maasai's traditional indicators for determination of climate change and variability related adversities	Observed adversities due to climate change and variability in the Maasai land
a. Decreasing trend of rainfall every years i. Rainfalls have become very unpredictable ii. Rainfall patterns have changed or shifted b. Increased frequencies of droughts/recurrent droughts), resulting in severe shortage of grasses and water for livestock	i. Appearance of certain insects, behavior of some animals, and movement of birds i.e. Kigong'oto / Ordilo, Ostrich Army worms (Enkurto), locusts (Irmaat) and some species of frogs. ii. Appearance of certain (alien) plant spp i.e. "Ottiameletet"-which means "an enemy of grasses", Oldepe, Oltelement etc, which are poisonous to livestock iii. Appearance of some stars i.e. "Ngakwa" iv. Intensity of flowering of some tree species such as Sausage tree (Kigelia Ethiopica) or ormukutan, oloponi tree (In Maasai) (Erythria spp); Olmoto tree Bauhimia spp) and certain Acacia tree spp)	i. Occasional heavy rainfall above normal causing floods ii. Drying of rivers and or decreased river flows. i.e. River Orkejuloongishu has dried out completely. iii. Increased frequencies and recurrence of uncommon livestock diseases, i.e. Lung disease(Orkipioi), Skin rashes (Enariri), Worms and water in the head (Ormilo), Diarrhea (Engortik) which require frequent treatment iv. Prolonged Drought v. Massive deaths of livestock vi. Transformation of grazing lands with most of its vegetation becoming bushy and thorny vii. Increased frequencies of Malaria ("Engonjan'gani") viii. Disappearance of short (Irkisirat) rainfalls
c. Extreme high temperatures for both human and livestock	i. Discharge of water from the leaves of Albizia Schimperiana ii. Extreme hot weather at nights in the months of September to November or low night temperatures in the same months. iii. Direction of the prevailing winds iv. Immature dropping of fruits and shading of leaves by certain tree spp i.e. sycamore fig (Ficus sycomorus)	i. Extreme high temperatures for both human and livestock ii. Severe shortage of milk, culminating into food insecurity (famine) iii. Some preferred grass species for cattle grazing have disappeared in the grazing lands i.e. Erikaru grass, Osankas, Emurua, Engapuru grass

high temperatures for both human and livestock resulting into too much stress to the livestock. According to the views of respondents obtained through FGDs, key informants interviews and questionnaires, the Maasai reported that they had been experiencing all these changes in climate since the late 1990s and 2000 - about the previous two decades. Earlier before that period, they were used to low rainfall but which was evenly distributed throughout the season as said by one of the respondents in the following quotation:

"We have lived in this area for many years. This area is as dry as you can see for yourself but rich in suitable grasses for livestock. We do not receive a lot of rainfall as it is the case with other localities like the coastal areas. We normally receive little rainfall but adequate for the growth of grasses and water for our livestock. In the past, such rainfall was predictable and reliable. We could easily predict the onset of rainfall at any time of the day or season. Even we could predict if it was going to be a good or bad season for our livestock. Depending on our predictions, we could plan for relocation to other suitable places well in advance if the year's prediction was a bad one. However, there is something seemingly wrong that has happened. Our traditional ways of forecasting weather are rarely working nowadays (Focus group discussant (Oloiboni) in Oltepasi Village).

In the past, the Maasai communities could use indicators such as the appearance of some stars famously known as 'Ngakwa" (in Maasai), to forecast the onset of rainfall season or on a particular day in a season as detailed in the following quotation:

"In the direction of sunset, usually there are two stars. One of these stars is brighter while the other one is less bright. If the brighter one surpasses the less bright one by coming on top of the other at around 7 pm it must rain, and if the less bright one appears on top of the brighter one it signals that the onset of rains would be interrupted by a dry spell and the beginning of drought season" (Elder & Key Informant (Iloibonok) in Oltepesi Village).

However, the elders admit that those stars are not commonly seen nowadays.

They admitted that very few of such indigenous or traditional means of forecasting changes in weather were still working. For example, the examination of a slaughtered animal intestine used to be a common way of forecasting weather events locally. The Maasai elders, for instance, would examine goat guts to see if they could be having watery cysts on them in the month of August. If watery cysts were found in the gut, it would be a strong and reliable indicator that there could be a lot of rainfall in the subsequent season. Conversely, if there were dry cysts in the gut in August, it would forecast weather events such as drought.

Results from the FGDs further revealed that prevailing winds are among the few remaining indicators in use for forecasting weather events. Based on this indicator, if prevailing winds blew from west to east in the months of September/ October they would signal the start of the rainy season. However, if the prevailing winds in August changed from the northern to the eastern direction, this would indicate low rainfall and hence drought was expected according to their traditional interpretation.

Maasai pastoralist communities in Longido District reported to have noticed a decrease in rainfall patterns since the late 1990s. Before that, rainfalls used to be adequate, more reliable and predictable as opposed to the recent phenomena as captured in the following quotation:

"In the past 10-20 years, there were no boreholes. Today, boreholes are everywhere due to changes in rainfall patterns. In the past, we used to receive heavy rains, and drought was followed by 7 years of predictable rains. Now that does not exist at all" (Elder "Iloibonok" & Key informant in Eworendeke Village).

It was reported further that, before the late 1990s, short rains (irkisirat) used to start in October until December, followed by a short dry spell (*Kiangazi kifupi*) in January and February after which came the main rain season (alari) in March-May. Alari is characterized by heavy rains. It was revealed further that the irkisirat rains started to be scarce and continued to be less year after year until early 2000 when they became almost nonexistent. Similarly, alari rains became scarce beginning to fall in April and stopping in May. The observed trends associated with changes and shifts in rainfall

patterns have become so frequent beyond the Maasai's traditional weather forecasts affecting their local ways or mechanisms of responding to adversities such as drought.

Maasai Pastoralists' coping strategies

Given all these, there is no doubt that pastoralism, which is the mainstay of the Maasai communities, is experiencing challenges such as declining productivity of both milk and meat, which constitute to their main or staple food. For instance, with the recurrent droughts, split herd mobility has become a major coping strategy in which herds of livestock are being split into groups and moved to distant but temporary kraals. Animals have to endure long-distance mobility in search of water and pasture, leaving the weak and the young ones at the main boma. All these stresses contribute to low milk production. With the animals moving to distant places, Maasai women have to follow them up for milking and bringing the little milk to the main boma where the children are left to stay. This is however laborious, time-consuming and stressful. Furthermore, due to recurrent droughts, controlled mating of livestock is highly practised to avoid calves or young animals being born at a time when there are not enough pastures and water for the lactating animals and their young ones. This is intentionally done to avoid or minimize the death of livestock as a result of drought, contributing further to reduced milk production. Pastoralist's plan is to ensure that calving takes place at the start of the short rain season (irkisirat), when there is adequate pasture for cows to yield more milk. In that way, calves stay healthy enough to survive their first dry spell in the months of January to February and benefit from the long rains before the long dry season sets in. On the other hand, meat production is also highly affected since animals become emaciated and lose market value. Increased incidences of pests and diseases are equally contributing to both reduced milk and meat production. As a result of all this, many Maasai pastoralists' households are now food insecure.

These practices inform us that the Maasai pastoralists traditionally used to have their own disaster early warning signs or indicators, which enabled them to take appropriate measures to prevent, prepare for and or mitigate envisaged disasters. This can be compared to an anticipatory (proactive) approach to risk management whose essence was the taking of no-regret measures.

Rainfall and Temperature Variability and Trends of Climatic Data

This study obtained data on climate change and variability and meteorological data for rainfall and temperature from Arusha meteorological station since Longido stations have not been operational for almost two decades, this was justified in Consultation with the TMA on the use of Arusha meteorological data set for Longido was justified due to the non-existence of such data sets within Longido District itself.. Thus, in this case, the limitation and the assumptions justify the use of Arusha data set to describe and analyse climatic changes and variations in the study area.. Several other studies such as those by Njau, *et al,* (2104), and Nderumaki, *et al,* (2016) have used data sets from the same station.

The results indicate clear decadal climate variability in Longido District. There is a declining trend for both rainfall and temperature across the study area (Fig. 2-9), with more changes noted in both short (irkisirat) and long (alari) rain seasons. For example, there was a decrease of almost 8 mm and about 7 mm of rainfall for both alari and irkisirat rainfalls respectively. The changes imply that a strong variation in rainfall amount and pattern over the previous 10 years in the study area with a decreasing trend. This was confirmed by statistical analysis on the slope of the trend line at 95% of significance for seasonal rainfalls and annual rainfalls, in which the slopes of the trend line are significantly decreased (Table 3). The presence of a statistically significant trend was evaluated using Z-value. In this case, the absolute value of Z was compared to the standard normal cumulative distribution to define if there was a trend or not at the selected level α of significance. A positive (negative) value of Z indicates an upward (downward) trend. In this case, the test statistics (Z) value is negative, indicating a decreasing trend, signifying that

there had been a consistent decrease in rainfall amount over time. Further analysis reveals a shift and change in mean monthly rainfalls and shift patterns of irkisirat and alari rainfalls (Fig. 10).

Extreme temperature events are associated with heat stress on livestock, drying of rivers and other water points and shortage of pasture and disappearance of some preferred grass species for use as pastures. Furthermore, the occurrence of pests and disease outbreaks is attributable to extreme temperature events.

Table 3: Summary of test statistics (Z) in seasonal and annual rainfall amounts

Station(s)	Record length (Years)		Seasonal Trends				
	From	To	Short rains (*Irkisirat*) (SON)	Intermediate season (DJF)	Long rains (*Alari*) (MAM)	Dry season (JJA)	ANN
Longido/Arusha	1983	2013	-1.85	-0.115	-1.41	-2.62	-5.995

Analysis of 30 years' time series data for temperature in Longido indicated evidence of climate change and variability with increasing trends of both minimum and maximum temperatures in line with the declining trend of rainfalls. The trend shows that Longido District has warmed for about 0.6 degrees for the last 30 years (Fig. 7-9).

Discussion

The results on perceived changes in climate are in agreement with the results of a trend analysis of timeline climatic data for 30 years obtained from the Tanzania Meteorological

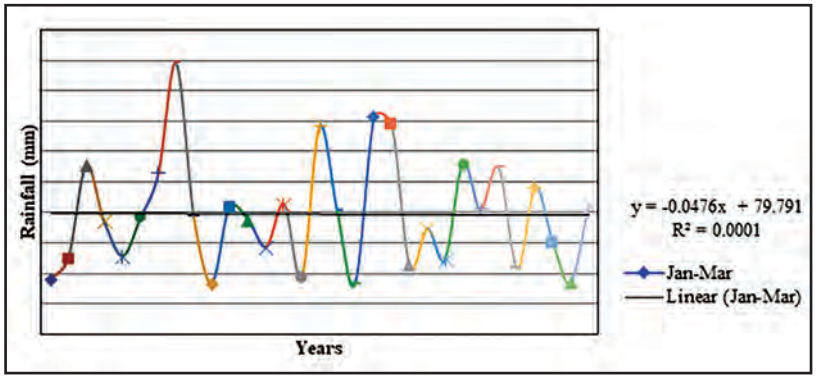

Figure 3: Rainfall total (Jan-March) 1983-2013

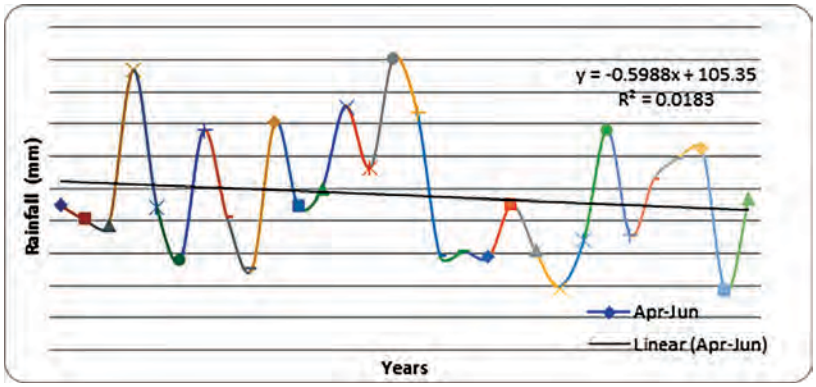

Figure 4: Rainfall total (April-June) 1983-2013

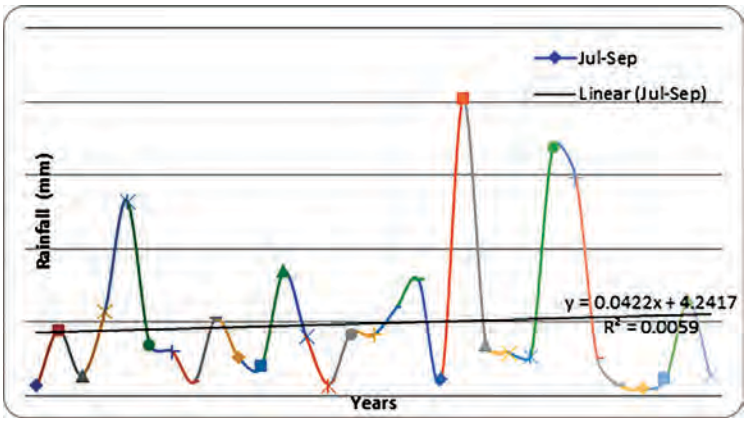

Figure 5: Rainfall total (July-September) 1983-2013

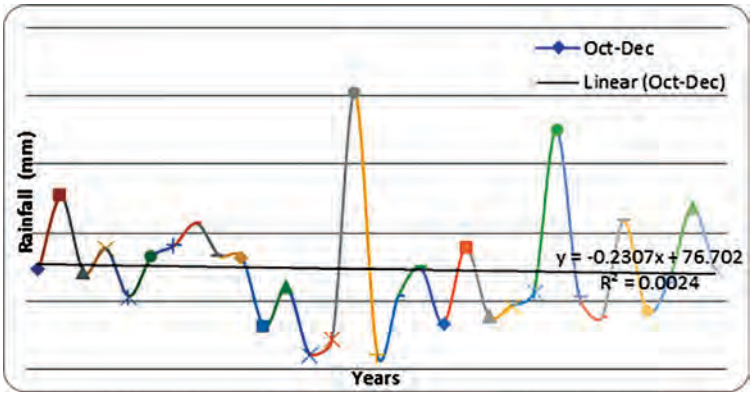

Figure 6: Rainfall total (October-December) 1983-2013

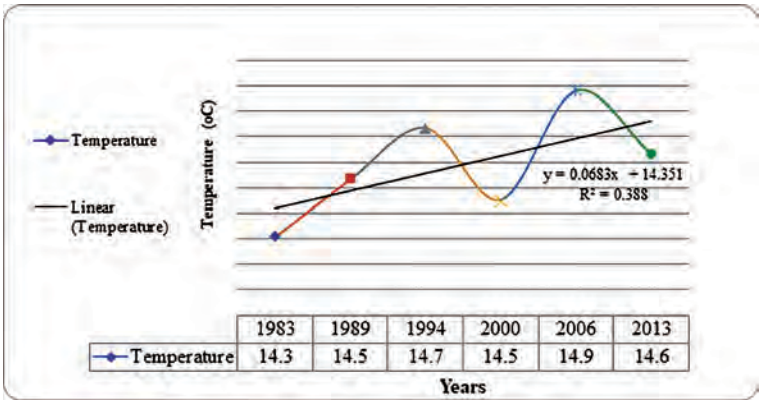

Figure 7: Mean minimum temperature for Longido District (1983-2013)

Agency (TMA), which shows a general declining trend in the amount of rainfall, increased dry spells (droughts) and increased temperatures for the previous two decades (Fig. 2). The results show that the Maasai pastoralists have a keen awareness of the changing climate and variability and are able to identify and relate weather extremes with the associated adversities.

The finding with respect to Maasai pastoralists' perceptions and traditional indicators of climate change and variability were in line with Mhina (2006), who also noted that reading signs on goat intestines among the

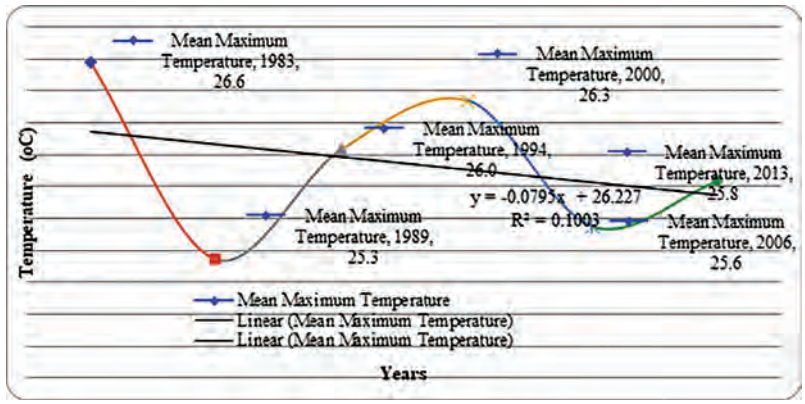

Figure 8: Mean maximum temperature for Longido District (1983-2013)

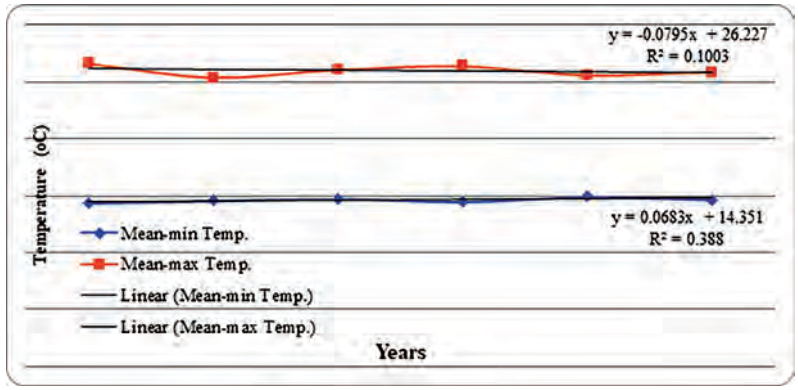

Figure 9: Mean minimum and Mean maximum Temperatures for Longido (1983-2013)

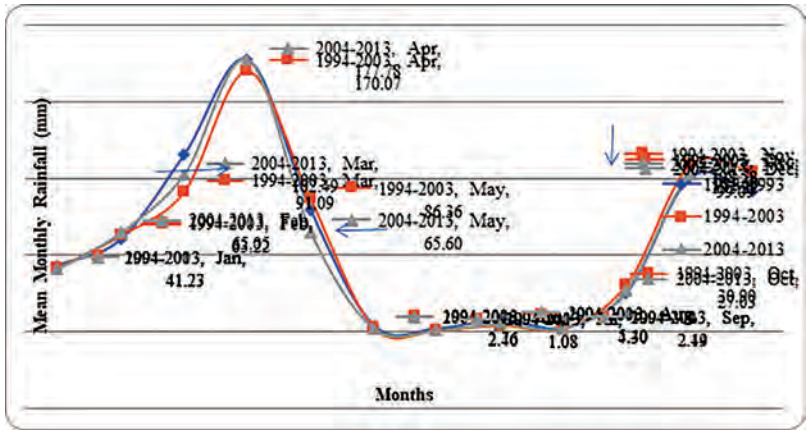

Figure 10: Shift and change of mean monthly rainfalls and shift pattern of short (*irkisirat*) and long (*alari*) rainfall seasons

Maasai pastoralists was used to forecast other events such as famine, social conflicts, disease outbreaks, child birth, etc. However, it was generally agreed by both FGD discussants and key informants that nowadays reading goat intestines is misleading. Apparently, they are mainly dependent on the behaviours of animals themselves in forecasting weather events. For instance, if cattle start moving fast towards a particular direction with their heads raised upwards, it is a clear indication that it would rain sooner or later and the rain would come

from that direction. Conversely, if an animal (mainly cattle) passes urine that is characterized by lots of fumes before the onset of rainy season, it is a clear indication of an impending drought during that particular season. Other local indicators that are still used by the Maasai include peculiar cloudburst or thunderstorms (in Maasai *"Mdung'osu*), which come in September signalling the onset of a new rainy season, followed by sprouting of Oltepesi tees (Acasia spp), which turns greenish due to sprouting of new leaves. In addition, the appearance of insects such as armyworms and locusts is still strongly associated with the occurrence of drought and famine. Similarly, the shedding of leaves by a fig tree (Ficus sycomorus) has also remained a clear indicator of the onset of drought for the majority of the Maasai pastoralists.

According to Price *et al,* (2010) such proactive measures have benefits that could be realized even if no disaster happened. For instance, if drought was expected; some Maasai pastoralists in Orkejuloogishu Village would devise a new mechanism in which they would sell a significant number of their livestock herds, mainly cattle, and would keep the money accrued from the sales of cattle with "progressive" and "trusted" business people in the village. These highly trusted traders would keep the money until the crisis period was over, and the money would be returned to the owner for restocking. Thus, this is seemingly a win-win anticipatory approach as the pastoralists involved in this practice would not have experienced a total/complete loss of their stock even if the drought did not happen. Thus, this serves as a "traditional insurance mechanism" and one of the no-regret measures. As a way of strengthening these coping strategies, there is a need to foster them into permanent adjustment (adaptation) strategies to sustain pastoralism.

The results with respect to rainfall and temperature variability and trends of climatic data maintained a similar trend as what was analysed by Njau *et al.* (2014), who noted an increase of average annual temperature in Ketumbeini Ward of Longido District by 0.5 units, equivalent to 22.5°C to 23°C in 2010. These results are also in agreement with those reported by Mary and Majule (2009) from arid and semi arid of central parts of Tanzania, which have similar climatic conditions as those of Longido District.

Conclusion and Recommendations

It can be concluded from this study that, the district has warmed for about 0.6°C for the last 30 years, with increasing trends of both minimum and maximum temperatures in line with decreasing trend of rainfalls. This has in turn shifted the main rain seasons from October to April to May while the short rains (irkisirat) become almost nonexistent in the months of October to December.

The study reveals further that the Maasai pastoralist's perception and interpretation of climate change and variability is consistent with the results of statistical analysis of 30 years climatic data for rainfalls and temperatures. According to the Maasai pastoralists, climate change and variability is perceived by decreasing, erratic and unreliable rainfalls that is also increasingly becoming difficult to predict using traditional knowledge, increased temperatures and sun heat, increased incidences of pests and diseases for both people and livestock and change in vegetation type and communities associated with the disappearance of palatable pastures and introduction of alien but also poisonous or undesirable plant species for livestock.

The study shows that many of the Maasai's traditional ways of forecasting weather changes are no longer in use as they are rarely working nowadays posing serious challenges in their livelihoods. The coping strategies by the Maasai pastoralists in Longido District are mainly geared towards safeguarding their livestock from the negative impacts of climate variability. These include destocking through sales of animals before the critical onset of dry season, temporary migration to other localities in search of pasture and water for their livestock and domestic use (herd mobility), and controlled mating.

These coping strategies are however temporary adjustments to the negative impacts of climate change and variability. Thus, there is a need to upscale some of these coping strategies into useful and permanent (adaptation)

strategies. This, however, requires the support of the government because adaptation is expensive.

Acknowledgments

The authors are grateful to the Sokoine University of Agriculture for organising the 3rd Scientific SUA Scientific Conference on Enabling Environment in Agricultural Transformation Edward Moringe Campus, Sokoine University of Agriculture where an abstract for this article was first presented.

References

Ayantunde, A.A., Asse, R., Said M.Y. and Fall, A. (2014) 'Transhumant Pastoralism, Sustainable Management of Natural Resources and Endemic Ruminant Livestock in the Sub-Humid Zone of West Africa', Environment, Development and Sustainability 16(5): 1097-1117

Bailey, K.D. (1994). Methods of Social Research, The Free Press. A Division of Macmillan Inc., New York. Pg. 97.

Homewood, K., Lambin, E.F, Coast, E., Kariuki, A., Kikula, I., Kivelia, J.,Saidi, M., Serneels, S. and Thompson, M. (2001) 'Long-Term Changes in Serengeti-Mara Wildebeest and Land Cover: Pastoralism, Population, Or Policies?', Proceedings of the National Academy of Sciences of the United States of America 98(22): 12544-12549.

IPCC (2007) Climate change 2007: Synthesis report. Contribution of working groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Core Writing Team, Pachauri RK, Reisinger A (eds) IPCC, Geneva

IPCC, (2001a). Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC Third Assessment Report, Cambridge University Press.

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

IPCC, (2007). Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC, Cambridge University Press.

Kothari, C.R. (2005). Research Methodology. Methods and Techniques. New Delhi : New Age International (P) Ltd.

Mary, A.L. and Majule, A.E. (2009). Impacts of climate change, variability and adaptation startegies on Agricultre in semi arid areas of Tanzania. The case of Manyoni District in Singida Region, Tanzania. *African Journal of Environmental Sciences and Technology.* 3(8), 206-218

Mhina, M.S. (2006). Report on Nature Conservation and Natural Disaster Management-Role of IK in Tanzania. Tanzania Meteorological Agency (TMA),

Njau, F., Hyandye, C., Olais, L.J. (2014). Adaptation Measures to impacts of Climate Change in Tanzania: Case of Maasai Pastoralists in Ketumbeine Ward –Longido District. *International Research Journal of Natural and Applied Sciences,* Vol. 1, (1).

Odgaard R and F. Maganga (2013) External Evaluation of the Project‟ "Land Use Planning and Resource Management in Longido District", unpublished draft report, request at cords@habari.co.tz

Price, Sharon J, Price, Christine A, McKenry, Patrick C, editors. (2010): Families and Change: Coping with stressful events and transitions 4th ed.476pp.

Saunders M., Lewis, P. and Thornhill, D. (2007), Research Methods for Business Students, 4th Edition. Pearson Education Limited, London.

Saunders M., Lewis, P. and Thornhill, D. (2009), Research Methods for Business Students. Fifth Edition. Pearson Education Limited, London.

Stutely, M. (2003). Numbers Guide: The Essentials of Business Numeracy, London, Bloomberg Press,

URT, (2006). United Republic of Tanzania: Singida Region VISION 2020. Annual Report.

URT, (2013). Population and Housing Census‟, URT-National Bureau of Statistics Accessed 30th December 2014 http://www.nbs.go.tz

URT, (2014). Land and natural Resources: Available at http://www.arusha.go.tz/index.php/economic-activities/land-natural-

resource, Retrieved on 27th February 2104.

WVP, (2010). The Whole Village Project (WVP). Project Village Reports for Elerai, Eworendeke, Kimokouwa, Tingatinga, Kiserian, Sinya and Kitendeni in Longido District. Available at: http://wholevillage.umn.edu/documents/Longido.pdf

Nderumaki1,V, Mkanda, F.X., Saria, J.,(2016). Comparison of Food Insecurity among Agro-Pastoralists and Pastoralists Communities in Pastoral-Livelihood Zone of Longido District, Tanzania. *Journal of Food Security,* 4(1): 18-26.