THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Assessment of Magnitudes of Vulnerabilities to Drought in Pastoral Production System in Marsabit, Northern Kenya

Jiddah Choke Chufe

Ph.D. Student, School of Environment and Earth Sciences, Maseno, University, Kenya

Boniface O. Oindo

Professor, School of Environment and Earth Sciences, Maseno University, Kenya

Dr. Paul O. Abuom

Senior Lecturer, School of Environment and Earth Sciences, Maseno University, Kenya

Abstract:

Communities in arid and semi-arid lands are faced with a number of challenges including short and unreliable rainfall and recurrent droughts affecting large numbers of humans and livestock. The drought frequency and severity has increased and is negatively impacting on households. This has increased the vulnerability levels in households. However, the magnitudes of vulnerabilities on households are not well understood and documented. The objectives of this study are to assess magnitude of vulnerabilities to drought in pastoral production system. Simple cross-sectional random sampling was used for primary data collection through questionnaires. 384 households were randomly interviewed in a household population of about 19,000 households using the (Scott Smith, 2013) formula for deciding the sample size. Secondary data was obtained from relevant public reports, journals, agricultural reports, statistical abstracts and development partners. The study considered various biophysical and socio-economic factors to calculate Vulnerability Index. Weights for different indicators to calculate the household vulnerability index (HVI) was used. The household Vulnerability Index was constructed using Principal Component Analysis (PCA). Data analysis was done using frequencies, percentages, spearman correlation, cross tabulations and chi square tests. The results were presented using tables, bar graphs, pie charts and plates. The data was analysed through computer Excel and SPSS programmes. The presentation of results was done in form of narrative, graphs, tables, pie and bar charts. The results show that 2.3 % of the households were highly vulnerable, 32.6 % were moderately vulnerable and 65.1 % less vulnerable. The overall drought vulnerability for the study area was 0.46, indicating moderate vulnerability. This implies moderate support is required from external sources. In order to build community drought resilience camel keeping, development of strategic water resources and investments in rangeland reseeding and control of invasive plant species is necessary.

Keywords: Drought, vulnerability, pastoralists, arid and semi-arid

1. Introduction

Arid and Semi-Arid Lands (ASALs) make up more than 40% of the earth's surface and home to 35% of its population (GoK, 2012). The ASALs are prone to drought. Drought is a normal recurrent feature of climate, and is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard (Hagman, 1984). The data from Emergency Events Database (www.em-dat.net) show that, throughout the world, droughts account for 5% of the natural disasters and losses from droughts have caused up to 30% of all losses from disasters, ranking droughts first among all the natural hazards. Furthermore, with the escalation of global climate change, the frequency of droughts and the areas affected are expected to increase sharply (NCAR, 2005; IPCC 2001). Worldwide losses from droughts have increased significantly in tandem with the increased number and severity of droughts (Wilhite, 2000) in Zhao et al. (2010). However, despite the importance of drought, very limited studies have been carried out globally on drought vulnerability assessment.

Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001). Fussel and Klein (2006) explain that, the IPCC definition of vulnerability may be expanded into "integrated vulnerability (of a particular system over a specified time horizon) to anthropogenic climate change". This study heavily relies on the IPCC working definition of vulnerability, a function of exposure, sensitivity and adaptive capacity (Khajuria and Ravindranath, 2012). Vulnerability is typically described as a function of three overlapping elements including *exposure* to hazard, *sensitivity* to hazard and *adaptive capacity* explains Turner *et al.* (2003a). Vulnerability is a condition in which individuals face food insecurity (hunger), job insecurity (unemployment), social insecurity (power isolation), and insecurity of health (illness and physical weakness) (Zahedi Mazandarani and Zahedi Abghari, 1996 in Zarafshani et al., 2012). Complex interactions between socio-economic factors

and the environment are important in determining vulnerabilities of communities and households to climate change according to Busby *et al.* (2011). Results of impact and vulnerability assessments are then used to guide pre-drought planning and mitigation programs that diminish the risk of future drought impacts, and in turn lessen the burden placed on response-oriented management (Abraham, 2006). Drought risk management involves understanding vulnerabilities and mitigation programs which modifies operations before a drought strikes in order to reduce the impending harmful impacts (Zarafshani *et al.* 2012). Studies in Iran by Karami, (2009); Keshavarz *et al.* (2012; Zarafshani *et al.* (2012) show that national drought planning efforts are mainly based on 'crisis management'. However, making the transition from crisis to risk management is difficult because little has been done to understand and address the vulnerabilities and impacts associated with drought.

Panda and Dhanapal (2015), mention that vulnerability is a function of adaptive capacity. Panda and Dhanapal (2015), in a study conducted in India show that there is need for vulnerability assessment across key sectors. However, the methodology to do so is not clear. Baudoin *et al.* (2016) mentions community vulnerability assessment of Kaua'i an O'ahu in Hawaii on the Northern shores providing a mixed qualitative and quantitative critique of Early Warning System in these communities but could not share the details of what method was used. Drought Vulnerability Assessment data sources globally are non-uniform and some data sources present contradicting information (Delft, 1993). The impacts of natural hazards on society are increasing in incidence and severity in terms of economic costs and loss of life, a trend likely to continue due to increased vulnerability linked to drought, rapid population growth, rapid urbanisation and other unsustainable development trends (Baudoin *et al.*, 2016). Baudoin *et al.* (2016) explains that a high degree of vulnerability to natural hazards is often pointed out amongst the poorest households and those located in remote areas across the world especially, in the global south. They go further to explain that wealthier households are also vulnerable to hazards due to their location. CWCB (2013) used Numerical Assessment Tool for Vulnerability analysis in Colorado State, USA. However, the assessment of magnitudes to vulnerable is not clear.

Africa contains a substantial portion of the world's arid and semi-arid rangeland, extending over three million square kilometers and these arid zones support an estimated 16-22 million pastoral population (Widstrand, 1975) and nearly 500 million head of livestock (FAO, 1975; Lusigi and Oba, 1987). Recurrent droughts and famine are a common feature of African rangelands. This has been vividly illustrated in the Sahelian drought of 1969-1973 and the drought of 1983-1984 which claimed numerous lives (Oba, 2007). The people most affected by recurrent drought are the pastoralists and their livestock are decimated and reports at the time of drought estimated several million livestock starving accompanied by horrifying human suffering (Lusigi and Oba, 1987). The failure of the 2016 October-December rains across parts of the Horn of Africa has led to a devastating drought in Somalia, south-eastern Ethiopia, and northern and eastern Kenya and more than 15 million people in these three countries faced food and water shortages, and famine was experienced in Somalia (IAWG, 2016). The large-scale failure of rains during October-December 2016 led to a devastating drought across parts of the Horn of Africa, central and southern Somalia and south-eastern Ethiopia (IAWG, 2016). As observed by Hume *et al.* (2005), there has been relatively little work published on climate change research subjects for Africa including drought. A study conducted in the Greater Horn of Africa by Omondi *et al.* (2013) confirms that understanding the characteristics of climate extremes such as drought at regional and local levels is critical not only for the development of preparedness early warning systems, but is also fundamental in developing drought adaptation strategies. Some of the strategies are ecologically based, while others depend upon socio-economic and cultural mechanisms (Lusigi and Oba, 1987). Expanded social protection programmes, strengthened access to sustainable water, improved natural resource management, and implemented early warning systems and insurance schemes in Eastern Africa has positively contributed to drought resilience (IAWG, 2016). Despite the devastating effects of droughts, adequate studies on drought vulnerabilities of pastoral households have not been conducted in Africa.

An integrated drought vulnerability assessment approach which combines both socio-economic and bio-physical factors that includes all internal and external situations has been applied by Madu (2012) in Ethiopia in agro-ecological based household vulnerability study and by Deressa (2008) for regionally based vulnerability study. According to a study by Busby *et al.* (2011) in Eastern Africa, five factors were identified that interact to influence overall vulnerability to drought i.e. physical exposure, human induced environmental stress, population density, household vulnerability, governance and conflict. Complex interactions between socio-economic factors and the environment, additionally contribute towards determining the levels of vulnerability to drought.

In Kenya ASALs make up 80 % of the land area and home to 3 million persons (Ominde 1971, Wisner 1976). However, in 2007, 14 million live in the ASALs and approximately support 70 % of national livestock herd is supported (GOK, 2007b). Mbithi and Wisner (1972) and Wisner (1976) classified droughts in Kenya as being of national scope affecting more than 10 % of Kenya's population including losses of up to 50 % livestock herds. Kenya has identified its ASALs as the most vulnerable areas to drought with huge impacts on livestock rearing, small-holder agriculture and tourism, which are dominant sources of livelihoods in these areas (Onono *et al.*, 2016). The drought frequency has increased as 4 of the 28 droughts occurred in the last 10 years (Mude *et al.* 2009). In Northern Kenya, more than 3 million pastoralist households are regularly hit by increasingly severe droughts (Mude, 2009). For livelihoods that rely solely or partly on livestock, the resulting high livestock mortality rate has devastating effects, rendering these pastoralists amongst the most vulnerable populations in Kenya (Mude 2009). In the last 25 years Kenya has experienced prolonged dry periods that have affected millions of people and killed huge numbers of livestock - especially in most marginalised parts of the country, the Arid and Semi-Arid Lands (ASALs), (Ogwell, 2011). Severe droughts have been recorded in 1960/1961, 1969, 1973/1974, 1981/1981, 183/1984, 1991/1992, 1995/1996, 1999/2000, 2004/2006, 2008/2009 and 2010/2011 (Onono *et al.*, 2016). In northern Kenya, where dryness is most pronounced, 28 major droughts have been recorded in the past 100

years, (Schilling and Remling, 2011). According to pastoralists, rains use to fail every nine or ten years, while they now experience drought every two or three years (Schilling and Remling, 2011). The question arises, why does such a regular and predictable phenomenon lead to suffering, loss of livelihoods and sometimes loss of life? Lack of adequate information on magnitudes of vulnerabilities to drought on pastoral production systems has resulted in poor intervention measures.

From disaster records nationally, in the National Policy for Disaster Management, (2009), in 1975, 1977, 1980, 1983/1984, there were widespread droughts in Kenya that affected 20,000, 40,000, 4,000 and 200,000 persons respectively. In 1995/1996, there was widespread drought that affected 1.4 million persons nationally. The El Nino floods of 1997/1998 affected 1.5 persons nationally. In 1999/2000, there was a major drought in the country that affected 4.4 million persons. In 2004, the country experienced severe drought that affected 3 million persons needing relief food for a period of eight months. In 2006, there were floods in Laisamis that displaced 5,000 persons (NPDM, 2009). No adequate studies have been conducted to assess the vulnerabilities of local communities to various disasters including drought.

Kenya's arid and semiarid lands (ASALs), which have faced increasing drought frequency and intensity since the 1960s, are one of the most vulnerable and drought-prone regions in the world (Nkedianye et al., 2011). In the Arid and semi-arid parts of Kenya, which make 80 per cent of the dry land area, droughts are a common feature (GOK, 2007). Across Kenya, the effects of climate change are wreaking havoc (MEMR, 2009b.3). The prolonged droughts of the past decade have threatened food security and societal stability, especially in vulnerable pastoral areas (Economist 2009; GOK 2007b; UNDP, 2007). Kenya's economy is highly dependent on natural resource base, making it highly vulnerable to climate change (GOK, 2014). There is critical need for vulnerability and adaptation assessment and identify measures to be taken (MEMR, 2009a). There is need to identify the determinants of vulnerability and measure micro-level vulnerability of pastoralists in arid rangelands of Kenya (Deressa et al., 2008, Pearson et al 2008 and Sherwood 2013 and Opiyo et al., 2014). The country's vulnerability to drought differs depending on the area and this therefore calls for specific vulnerability assessment for each area (GOK, 2010). The identification of vulnerable areas to climate change related hazards and disasters has not been carried out in many counties in Kenya (Dhanapal, 2014). The vital information that is obtained from household level vulnerability analysis is presently lacking in national and regional level assessments (Opiyo et al., 2014). There is limited information regarding Kenya's vulnerability to the Climate Change and the level of knowledge and understanding is still more general according to a report of GOK (2010). There is limited research on drought vulnerability assessment among pastoralists in Kenya.

Due to climate change and drought phenomenon, Kenya's temperature has risen by 1 degree centigrade over the last 50 years (IPCC, 2007). The country is warming at the rate of roughly 1.5 times the global average and is projected to increase up to 2.8 degrees centigrade in 2060 and up to 4.5 degrees centigrade in 2090 (Schilling et al, 2011). Studies by Kabubo-Mariara (2009) and Silvestri et al. (2012) reveal that extreme weather events such as prolonged droughts and intense rainfall are already impacting negatively on pastoral communities in arid and semi-arid (ASALs) parts of Kenya. Studies by Kabubo-Mariara (2009) and Silvestri et al (2012) in Opiyo et al. (2014) reveal that extreme weather events such as prolonged dry spells and intense rainfall are already affecting rural communities in parts of arid and semi-arid lands (ASALs) of Kenya. The data sources for drought vulnerability assessment are non-uniform and some data sources present contradicting information (Delft, 1993). Vital data from households to assess vulnerability level is presently lacking at national and levels (Opiyo, 2014). There is no adequate data to carry out drought vulnerability assessment at the national level.

Elliot (2004) describes the challenges faced by the pastoralists in the study area as drought and famine, rapid population growth, loss of common property rights especially land, sedentarisation and rural urban migration. High levels of vulnerability to drought and adaptive capacity in the study area is linked to high reliance on natural resources, limited ability to adapt financially and institutionally, low per capita income, high poverty levels and lack of safety nets (PACIDA, 2009). Coping and adaptation mechanisms employed by the pastoralists included mobility, herd diversification, herd splitting/merging, sale of livestock, and livelihood diversification amongst others (Lekapana, 2013). A study conducted in Marsabit County by Lekapana (2013) indicates that livestock mortalities and morbidity, human morbidity, conflicts, food insecurity, reduction of livestock prices, and increase in food prices were among the socioeconomic impacts of drought experienced and factors contributing to vulnerabilities. Pastoral communities in Marsabit County have employed a number of coping and adaptation strategies to combat the effects of recent droughts on their livelihoods (Lekapana, 2013). However, due to poor documentation and inadequate research, there is limited knowledge on pastoralists drought vulnerability levels (Lekapana, 2013).

2. Materials and Methods

2.1. Study Area

2.1.1. Location and Demographic Characteristics

Marsabit County borders Ethiopia to the North and North East, Wajir County to the East, Isiolo County to the South and South West and Turkana County to the North West and Sumburu County to the West. Marsabit is the largest county in the country covering 70,961 sq. km. with a population density of 4 persons per sq km. Marsabit County has a population of 291,166 (2009) and a current estimated population of 310,000 persons. There are four parliamentary constituencies including Moyale, Sakuu, Laisamis and North Horr in the county. The study area covers the arid parts of Laisamis constituency including four electoral Wards including Laisamis, Loglogo, Korr and Ngurunet. The study area is in Laisamis Sub-County covering approximately 20,290. 5 sq. km with an estimated population of 65,000 persons

(Population Census, 2009). The study area ranges from 1°20'N to 3°15'N latitude and from 36°30'E to 38°E longitude, spanning lowland with an elevation of nearly 500 m above sea level (Figure 2.2).

The study area, Laisamis, in Marsabit County is isolated and undeveloped compared to the rest of the country, where the major populations live in the central highlands, Lake Victoria, and the Indian Ocean Coast. With low rainfall and few rivers, its deserts and mountains are inhabited mainly by nomadic pastoralists, including Turkana, Samburu, Rendille, Boran, Gabra, and Somali (Fratkin et al 2004). The poverty level is 92 per cent (Kenya Population Census 2009) for Marsabit County. The county livelihoods include nomadic pastoralists, semi pastoralists, agro pastoralists, small businesses and employment. The main economic activity in Laisamis Constituency (the study area) is livestock rearing. The economy almost entirely revolves around livestock rearing i.e. camels, cattle, sheep, goats and donkeys. Almost each household keeps livestock and facets of livestock industry impact on all other economic and social segments. The main livestock kept in the study area include camels, cattle, sheep and goats while crop production is only limited to few areas with shallow wells and micro-irrigation facilities. The study area is mainly inhabited by Rendille, Samburu and Ariaal communities, who are considered to be the most efficient producers of livestock under nomadic pastoralism. Few ethnic Somali community members practicing trade in food commodities and livestock are found in the trading centres including Korr, Loglogo, Ngurunet and Laisamis Trading Centre.

2.1.2. Geophysical Characteristics

Most of the study area is generally extensive plains lying between 530-760 m a.s.l. Chalbi desert, an old saline lake bed, lying at altitude of 435-500m a.s.l is the lowest land surface in the study area. The Chalbi desert marks the northern boundary of the area, while Mt. Kulal (2355 m) marks the western boundary and the Ndoto Mountains (2885 m) and the Mathews Range (2688 m) mark the southwest boundary. The main landforms in the study area are sedimentary plains, volcanic plateaus, volcanic orgneissic ranges and hills. The rest of the study area consists of rocky, stony and rugged lava plains and sandy clay loams on alluvial plains and basement rock. The Chalbi area is completely devoid of plant life, due to its salinity, and in some other isolated areas the soils are too acidic to allow the growth of vegetation.

Rainfall is unreliable and bi-modally distributed (theoretically) with two seasons per year. Frequent rain failures occur leading to high risks of prolonged droughts. In Northern Kenya, droughts used to occur on average every five years but due to climatic variations, droughts occur more frequently and severely (Schwartz et al., 1991). Most of the Rendille and Samburu population live in the central lowland, which is known as the Kaisut Desert. The average high temperature in shade is 39°C and the average low is 22°C, with little annual variation (Sun, 2005). The extensive daily sunshine leads to a great deal of global radiation and low humidity. Rainfall patterns in the lowlands are both low and unpredictable, with an annual rainfall averaging less than 200 mm per annum. The rainfall figures for the study Sub-County, Laisamis, range from 200 mm – 750 mm per annum. The rainfall is erratic and unreliable resulting in recurrent droughts and floods. This has increased the community's vulnerabilities towards climate change related hazards, exacerbated by high poverty levels, poorly developed infrastructure and socio-economic marginalisation.

The study area comprises mainly of two ecological zones i.e. Ecological Zone V and VI. Zone V area fall between 700m and 1000m, and covers Kaisut, Milgis and part of the slopes of Mt. Marsabit. The dominant vegetation consists of mixed acacia woodland on stony soils and acacia-cammiphora bushland on deeper soils. The grass consists of tufted annual grass that is suitable for cattle. Grazing in this zone starts at the onset of the dry season and lasts for 3 to 7 months, during which time the livestock herds gradually prepare to move to the permanent watering points. Ecological Zone VI covers areas lying below 700m. The annual grasses are poor and irregularly distributed. The high rates of evaporation and salt deposits inhibit the growth of grasses, particularly in Chalbi desert. The grazing season is short, lasting about 2 months after effective rains. When rains fail only camels and goats can graze in the area, (Njoroge, 2010). While over 30% of the study area is not fully utilized due to lack of water and insecurity, slow land adjudication process, conflict between communal land use and private ownership and wildlife conservation further inhibit full exploitation of the remaining land, and these problems also constrain conservation measures. If these constraints were overcome, more land would be available for both livestock and other economic activities. This would increase the overall study area livestock carrying capacity and reduce the rapid degradation of the fragile ecology.

The study area is characterised by wooded grassland, bushland and thicket, semi-desert grassland, and desert (Lind & Morrison, 1974; Sato, 1980; Sun, 2005). *Acacia tortilis* (*dahar*) is prominent in the upper strata, while the middle strata are fairly clear of vegetation, and grasses dominate the lower strata. Cattle and small stock (goats and sheep) are herded in the high elevation areas, but camels rarely come to these places owing to the high humidity, altitude, abundance of harmful insects that transmit livestock and human disease, such as ticks, tse tse flies and mosquitoes. The bushland and thicket zone extends from an elevation of 600 to 1200 m, and is found both at the foot of the mountains and in the lava area. *Acaciatortilis* and *Cordia sinensis* (*gaeer*) are conspicuous in the upper strata, while the lower strata are covered with shrubs such as *Sericocomopsis pallida* (*giib*) and *Duosperma eremophilum* (*yabah*). This vegetation zone covers approximately 40% of Rendille land, and is used by all species of livestock. Semi-desert grassland extends from an elevation of 400 to 600 m, and covers most of the central lowland of Rendille land. Trees more than 3 m high can be found only along the stream beds. Thorny trees less than 2 m (*Acacia* spp. or *Commiphora* spp.) are scattered throughout the middle and upper strata. The lower strata include sandy lands stippled by patches of bushes and herbs, such as *Sericocomopsis pallida*, *Duosperma eremophilum*, *Indigofera spinosa* (*kholo*) and *Blepharis linariifolia* (*Iemaru*). This vegetation zone accounts for approximately 40% of Rendille land, and is mainly exploited by camels and small stock. More than 80% of Rendille land is used for pasture. The vegetation species and quantities of plants are strongly influenced by topography and rainfall. Plant ecology is important for the Rendille's livestock management strategies.

Figure 1: Map of Kenya Showing Marsabit County
Source: Kenya Maps, 2012

Figure 2: Marsabit County Map Showing the Location of
Laisamis Sub-County
Source: County Maps, 2012

Figure 3: Detailed Map of the Study Area Showing the Study Wards I.E. Korr/Ngurunit, Loglogo and Laisamis Wards
Source: IEBC 2012

2.2. Research Design

The study area was selected because it is highly prone to drought as compared with the rest of the county. Four most drone prone wards were selected including Ngurunit, Korr, Loglogo and Laisamis resulting in four study locations. The total number of households was obtained from Kenya Bureau of Statistics Records (2009) for the area. Descriptive cross-sectional sampling was done. The sample size was selected based on sample size formula of Scott Smith, (2013). For the selected households whose heads were absent, the next senior household member was interviewed. A total of 384 households were interviewed in the four sites. The questionnaires used were based on the three objectives of the study i.e. Vulnerability Assessment, Identifications of drought adaptation options and assessment of drought impacts. The unit of analysis was the household because drought is directly related to household vulnerability, impact on household and adaptation decisions are made mainly at household levels. The household was selected as the main unit of analysis because major decisions about adaptation to climate change-induced stresses and livelihood processes are taken at that level. Nevertheless, households are connected to the wider community, which can greatly influence their decision-making processes in relation to use of particular productive resources (Opiyo et al, 2014).

2.3. Study Population

The study covered four Locations including Ngurunit, Korr, Log Logo and Laisamis within Laisamis Sub-County, Marsabit County. The population for Ngurunit was 6,058, Korr, 9100, Laisamis, 6,424 and for Loglogo is 5,144 persons (Kenya 2009 Population and Household Census). The household numbers were 1,665 for Ngurunit, 1,619 for Korr, 1,705 for Laisamis and 1,193 for Loglogo (Kenya 2009 Population and Household Census). 384 households were sampled through use of questionnaires. Three questionnaires were used i.e. one for each study objective including drought vulnerability assessment, drought adaptation options and impacts of drought on the community. Proportional allocation of questionnaires was done depending on the size of the population of the village. Thus, in Ngurunit 80 households, Log Logo, 90 households, Korr, 106 households and in Laisamis 108 households were interviewed. The sampling was randomly done by skipping every two households in a transect walk.

2.4. Sample Size

The Sample Size was identified through the formula described below derived from Scott Smith, 2013:
Necessary Sample Size is = (Z-Score) squared X Standard Deviation (1-Std. Deviation)/ (Margin of error) squared
Margin of Error (Confidence Interval) chosen is - + 5 %, Confidence Level is 95 %, and the Standard Deviation of 0.5 to ensure that the sample size is large enough. Z-Score for 95% Confidence Level from Z-Score Table is 1.96. Therefore, the formula for my sample size is:

Used Z-Score for: 95 % accuracy – i.e. 1.96

90% " - 0.645

99% " - 2.326

Sample Size = (1.96) Squared X Standard Deviation (1- Standard Deviation)/(Margin of Error) Squared
= 3.8416 x 0.25/0.0025
= 384 Respondents

2.5. Data Collected

Data was collected over a three-month period from 1 st. March - 30 th. May 2015. Data were collected on rainfall and temperature for the last 30-50 years. Rainfall and temperature data was obtained from Kenya Meteorological Service (KMS). Other key data collected include, demographic information, drought sensitivity on socio-economic systems, drought exposure, drought adaptive capacities, drought adaptation options and drought impacts.

2.6. Data Collection Process

Initial survey of the study area was conducted prior to the beginning of the study five months in advance. The objective was to identify the possible areas for the study and prepare for working relationship with the leadership of the relevant communities. This initial survey enabled a better understanding of the peculiarities of the study area, size of the sample, identification of local enumerators for the household interview. 16 local enumerators were identified i.e. four enumerators for each of the four villages. The enumerators were given one-day training to minimize bias and errors in data collection and to familiarize the enumerators with the objectives of the study. Pretesting of questionnaires was done on 15 households in Loglogo and the questions adjusted accordingly. The pretesting was done to check the suitability of the tools and also whether the enumerators could pose the questions without difficulty.

The pretested questionnaires were not included in the final results analysis for the study area.

2.7. Primary Data Collection - Vulnerability Assessment

384 Household Questionnaire was administered to four villages through proportional allocation. The questions in the questionnaire are based on climate exposure, sensitivity and capacity gaps. 90 households in Loglogo, 108 households in Laisamis, 106 households in Korr and 80 households were interviewed in Ngurunet. The questions in the questionnaire include demographic information, drought *sensitivity* including diseases to humans and livestock, livestock and human deaths due to drought), natural resources (water, vegetation, wildlife). Drought *exposure* questions include human, livestock and natural resources. To avoid misinterpretation, the household interviews were conducted in local languages including Rendille and Samburu.

Village	Number of Households	Population	Number of Respondents
Log Logo	1,193	5,144	90
Laisamis	1,705	6,424	108
Korr	1,619	9,100	106
Ngurunet	1,665	6,058	80
Totals	6,182	26,726	384

Table 1: Sampled Villages

2.8. Secondary Data Collection

Secondary data was collected from meteorological stations (Kenya Meteorological Services), Government of Kenya reports, NGOs' reports and County Government reports. Other data was collected through observations, listening and photography. The secondary data collected include rainfall and temperature from the meteorological stations in the study area and Marsabit Town. Records on frequencies of droughts and floods were obtained from the relevant GOK authorities in the Sub-County. Rainfall and temperature data over 30 - 50 years was collected. The data sets obtained include mean monthly rainfall averages together with minimum and maximum temperatures. However, there were some missing rainfall and temperature data for some centres in the study area including Korr, Ngurunet, Longlogo and Laisamis. Trends in temperature and rainfall deviations were recorded. Observations and photographic data and hearings were also used to enrich the secondary data. Additional secondary data were obtained from existing literature including published reports and other relevant sources.

2.9. Data Analysis

Primary data obtained was analysed through SPSS Version 20 and MS Excel programmes. Drought Vulnerability data including exposure, sensitivity and adaptive capacity was analysed through SPSS where weighed codes were assigned to each variable within exposure, sensitivity and adaptive capacity. The maximum weight index was 1, while the minimum was 0. Vulnerability Index was analysed by combining the mean of sensitivity and exposure and deducting from the adaptive capacity. The results from drought vulnerability assessment are given in form of indices i.e. from maximum of 1 to minimum of 0. Index of 1 indicates the households are highly vulnerable, 0.5 indicates medium vulnerability, while 0 indicates low vulnerability. Data on rainfall and temperature was analysed from the study area over 10 – 50-year period depending on data availability from the various trading centres. The rainfall and temperature data was useful in providing indications of drought years in the study area over a long period of time.

3. Results and Discussions

3.1. Socio-Demographic Characteristics of Respondents

A total of 384 households we interviewed and the distribution is, 28.1 % (n=108) were from Laisamis Center; 23.4 % (n=90) from Loglogo; 27.6% (n=106) were from Korr and finally 20.8% (n=80) were from Ngurnet (Figure 4). The

percentages and numbers indicate the households interviewed out of the total 384. n represents the number of households interviewed per enumeration area.

Figure 4: Enumeration Proportions

In Ngurunet 82.5 percent of the respondents were female while 17.5 per cent were male. In Korr 86.8 per cent were female while 13.2 per cent were male. In Log Logo 97.8 per cent were female while 2.2 per cent were male. In Laisamis, 73.1 per cent of respondents were female while 26.9 per cent were males. The percentages and numbers of households interviewed and gender representation is indicated in figure 4.2. The gender distribution does not necessarily represent the head of household; rather it represents the gender of the household who was available to be interviewed. However, in some cases, the female gender was heads of households. Some women were single mothers or widowed. The female headed households or widowed households are likely to be more vulnerable to drought related stresses. This is consistent with a study by Opiyo et al. (2014) conducted in Turkana County. The study has shown that female-headed households, divorced and widowed person's households with experience of less than 5 years in the area, are disproportionately likely to be affected by climate stresses and variability (Opiyo et al, 2014).

In times of climate stresses and shocks like drought, these categories of households tend to have fewer options to find other ways of making a living, because their very low levels of literacy reduce their opportunities in coping mechanisms such as wage employment. Similarly, female or divorced and widowed household heads are likely not to be empowered enough in pastoral communities to make household decisions and are frequently without access to credit services and adequate capital assets or not able to own large herds of livestock to manage households' daily requirements (Nabikolo et al, 2012). Similar observations have been made by Kakota et al. (2011) in Malawi and Tesso et al. (2012) in Ethiopia.

Figure 5: Distributions by Gender

The largest group from all the enumeration areas is between ages 36-60 years with the least being the age groups above 61 years. The age group of 36–60 years is the most active and productive age among the respondents. Categories in age group above 61 are more vulnerable because they have no adequate energy to engage in economic activities. The household with population of 2 under all age groups is the largest, Under 5 years (43.2%), 6-18 years (29.9%), 19-64 years (52.3%) except for those above 65 years (55.3%) with the highest population of size (Figure 6).

Figure 6: Age Distribution in the Study Area

Households with more dependents are more vulnerable than households with less dependents. In urban set up, the existence of the dependents may enable the provider, such as a parent or guardian, to claim income tax relief deduction. However, in a pastoral set up, the dependents rely on individual household heads to provide food, shelter and other basic services, resulting in pressure on the household head and the entire household. In consistent with the study findings, Opiyo et al. (2014) found out that in Turkana, the determinants of households' vulnerability were found to be significantly influenced by size of the household, number of dependents, household head, marital status and social linkages. The results are also consistent with previous findings by Kakota et al. (2011) and Gebrehiwot and vander Veen (2013). The household size distribution for the study area is as indicated in Figure 7.

Women play significant role in the household decision making among the pastoralists. There were 82 - 98 % women respondents in the four enumeration areas. The study communities comprise 52.3 % of 19 - 64 age groups, which is the most economically productive group. This implies that the community has adequate human resources to engage in economic activities. For example, households with more productive categories are less vulnerable than the categories with less productive ones. Less productive categories are more likely to be vulnerable compared with the productive category (Opiyo et al, 2014). Elderly household categories are probably worse off in terms of preparing strategies to cushion their families against adverse climatic stresses and impacts and are likely to be more vulnerable (Opiyo et al, 2014).

Figure 7: Household Sizes

From the bar graph above, male headed households with 2 dependents were 25 per cent of respondents, while with 3 dependents and above were 75 per cent for the study area. For female headed households, the households with 2 dependents were 23.2 per cent, while with 3 dependents were 26.6 per cent for the study area. We further went ahead and analysed the composition by the enumeration areas and the output was as below (Table 2). The table indicates the male and women headed households, the number of members in each household, the frequency, and the percentages of household members interviewed in each area including Laisamis, Loglogo, Korrr and Ngurunet. In Laisamis male headed households with 2 members were most frequent at 28.7 %, in Loglogo, male headed households with 3 members were most frequent at 34.4 %, in Korrr male headed households with 3 members were most frequent at 27.4 %, while in Ngurunet male headed households with 3 members were most frequent at 31.3 %. The male headed households with lowest frequency with 13 members in Laisamis was 0.9 %. In Loglogo male headed households with lowest frequency were 6 members at 2.9 %. In Korrr, male headed households with 8 members was least frequent at 0.9 %, while in Ngurunet male headed households with 5 members was least frequent at 8.8%.

Female headed households with highest number of members in Laisamis was 2 at 24 %, in Loglogo is 3 at 28.9 %, in Korrr is 3 at 34 %, while in Ngurunet is 2 members at 26.3 %. Female headed households with 11 members had lowest frequency in Laisamis. In Loglogo female headed households with 6 members was least frequent at 1.1 %. While in Korrr,

female headed household with 7 members was less frequent at 0.9 %. In Ngurunet, female headed household with 5 members was the least frequent at 11.3 %.

Enumeration Area	Male Headed Household			Female Headed Household		
	Household size	Frequency (n)	Percent (%)	Size of Household	Frequency(n)	Percent (%)
Laisamis	1	9	8.3			
	2	31	28.7	1	19	17.6
	3	22	20.4	2	26	24.1
	4	22	20.4	3	25	23.1
	5	10	9.3	4	14	13.0
	6	7	6.5	5	14	13.0
	7	4	3.7	6	5	4.6
	8	2	1.9	7	2	1.9
	13	1	.9	11	2	1.9
	Total	108	100.0	Total	108	100.0
Loglogo	1	13	14.4			
	2	22	24.4	1	11	12.2
	3	31	34.4	2	20	22.2
	4	12	13.3	3	26	28.9
	5	5	5.6	4	24	26.7
	6	3	3.3	5	7	7.8
	7	2	2.2	6	1	1.1
	8	2	2.2			
	Total	90	100.0	Total	90	100.0
Korr						
	1	13	12.3	2	22	20.8
	2	21	19.8	3	36	34.0
	3	29	27.4	4	20	18.9
	4	22	20.8	5	10	9.4
	5	11	10.4	6	7	6.6
	6	5	4.7	7	1	.9
	Total	106	100.0	Total	106	100.0
Ngurnet						
	1	11	13.8	1	12	15.0
	2	22	27.5	2	21	26.3
	3	25	31.3	3	15	18.8
	4	13	16.3	4	17	21.3
	5	7	8.8	5	9	11.3
	Total	80	100.0	Total	80	100.0

Table 2: Laisamis Sub-County - Size of Households Headed by Males and Females

Generally, in Laisamis Sub-County, the dependents were as below in Figure 8 according to the size of the households and age groups. The vertical part of the graph indicates percentages of each age group in the households, while the horizontal part of the graph shows the number of members in each household. The color coded bar charts indicate under-fives, 6-18 year olds, 19 - 64 year olds and household members above 65 years of age. According to the data, the household with population of 2 appear to dominate, while households with 1 member follows. Households with 3 to 4 members are moderate, while households with 5 – 16 members are rare in age category (Figure 8).

Figure 8: Size of Household by Age Group

From the study area, a greater percentage, 54 % of the pastoralists were unemployed with just 2 percent (2%) being employed. 93.8% of the households do not have formal education in the study area. Only 1.3 % has limited primary education and a negligible number had secondary education. The proportion with no formal education is the highest of all ranging from 85 - 90 %. This scenario implies that the target pastoralists are highly vulnerable to drought related stresses because they cannot access early warning information or read livestock extension materials. This finding is consistent with finding of a similar study by Opiyo et al (2014) in Turkana.

3.3. Magnitude of Vulnerabilities to Drought in Pastoral Production System

Many countries across the globe are adopting assessment of climate change vulnerabilities in their zones as a strategy to design strategies for interventions. This study sought to determine the magnitude of vulnerabilities to drought in the study area in order to provide area specific estimate of socio-economic and ecological implications. The study sought to assess vulnerabilities of all resources of the study area to provide detailed local information on the distribution, density and the state of the resources on the impact of hazardous events in this case drought.

3.3.1. Drought Vulnerability Index

The vulnerability index development is given as developed by the Intergovernmental Panel on Climate Change (2012) that vulnerability is seen as the net effect of adaptive capacity (socio-economic) and sensitivity/exposure (biophysical):

$$\text{Vulnerability} = (\text{Adaptive capacity}) - (\text{Sensitivity} + \text{Exposure}) \quad \text{Vulnerability} = \text{Adaptive Capacity} - \text{Sensitivity} + \text{Exposure}$$

When the adaptive capacity of the household exceeds that of its sensitivity and exposure, the household becomes less vulnerable to climate change impacts and the reverse is also true. As explained in the foregoing, each set (adaptive capacity, sensitivity and exposure) is composed of different variables. The model specification further looks like

$$V_i = (A_1X_{1i} + A_2X_{2i} + \dots + A_nX_{ni}) - (A_{n+1}Y_{1i} + A_{n+2}Y_{2i} + \dots - A_{n+n}X_{ni})$$

Where V_i is the vulnerability index, while X_s are elements of adaptive capacity, and Y_s are elements of exposure and sensitivity. The values of X and Y are obtained by normalization using their mean. Principal Components of Adaptive Capacity, Exposure and Sensitivity are allocated weights ranging from a scale of 0 - 1.

The whole matrix of variables of adaptive capacity (X_{ij}) and variables of exposure and sensitivity (Y_{ij}) will be summed and averaged.

The weighed variables of adaptive capacity will be summed and averaged.

Finally, the Vulnerability Index of each household is obtained using equation:

$$(VI) = \text{Adaptive Capacity} - (\text{Sensitivity} + \text{Exposure})$$

The higher the value of the index, the higher the vulnerability to drought and lower the value, the less vulnerability the house hold is and vice versa. The scale of analysis is important in this study is 0 – 1. Zero being the lowest and 1 being the highest.

In this study, the households were classified into three categories based on the value of their vulnerability index, which puts households into highly vulnerable, vulnerable and less vulnerable. These fractile intervals were used to characterize the various stages of vulnerability i.e.

- Less Vulnerable if the value is 0.0 – 0.49
- Moderately vulnerable is value is 0.5 – 0.69
- Highly Vulnerable is value is 0.7 – 1.0.

The higher the value, the higher the vulnerability and vice versa. The values presented are not absolute. The value represents relative measure, representing the household vulnerabilities.

From the study findings, high proportion of the households in the study area, 65.1% are *Less Vulnerable* with the Vulnerability Index being between (0.0 to 0.49). 32.6 % of the households were *Moderately Vulnerable* with 0.5 - 0.69 Vulnerability Index. Whereas 2.3% are *Highly Vulnerable* with Vulnerability Index of 0.7 - 1.0 (figure 3.6).

In this study, the households were classified into three categories based on the value of their vulnerability index, which puts households into highly vulnerable, vulnerable and less vulnerable categories. However, the index computed is not based on the thresholds or presents an absolute value. It is a relative measure, representing the households' own perception of how they have been coping in the past compared to other households.

When the adaptive capacity of the household exceeds that of its sensitivity and exposure, the household becomes less vulnerable to climate change impacts and the reverse is also true. The households that are highly exposed to climate shocks are more sensitive to damage, assuming constant adaptive capacity. The implication is that a higher net value indicates lesser vulnerability and vice versa. The index computed is not based on the thresholds or presents an absolute value. It is a relative measure, representing the households' own perception of how they have been coping in the past compared to other households. (Opiyo et al 2014 concurs with this observation in this study).

A high proportion of the households in the study area, 65.1% are *Less Vulnerable* with the Vulnerability Index being between (0.0 to 0.49). 32.6 % of the households were *Moderately Vulnerable* with 0.5 - 0.69 Vulnerability Index. Whereas 2.3% are *Highly Vulnerable* with Vulnerability Index of 0.7 - 1.0 (figure 3.6).

Figure 9: Drought Vulnerability Index for the Study Area

In Laisamis enumeration area, 75.9% of households are Less Vulnerable with an index of between (0.0 to 0.49) and just 1.9 % of the households are Highly Vulnerable. While 22.2 % of the households were Moderately Vulnerable. For Loglogo, 62.2 % of the households were Moderately Vulnerable with an index of between (0.50 to 0.69) with 4.4% being very Highly Vulnerable. 33.3 % households were Less Vulnerable in Log Logo. In Korr enumeration area, 69.8 % of the households were Less Vulnerable with an index of between (0.0 to 0.49), 28.3 % of households were Moderately Vulnerable while 1.9 % of households were Highly Vulnerable. In Ngurnet enumeration area, 80 % of the households were Less Vulnerable with an index of between (0.0 to 0.49), 18.8 % of the households were Moderately Vulnerable. While 1.3 % of the households were Highly Vulnerable (Figure 10).

Figure 10: Vulnerability Index per Enumeration Area

In regards to the enumeration areas, the vulnerabilities varied as indicated below (Figure 11).

Figure 11: Vulnerability Index, Line Graph

For Laisamis, Korrr and Korrr the Vulnerability Index was 0.42, 0.45 and 0.42 respectively, which implies that households in the areas are Less Vulnerable. Whereas for Log logo the index is 0.54 implying that it is Moderately Vulnerable. From the above findings it clearly shows that Laisamis Sub-county is less vulnerable with 0.46 Vulnerability Index.

Figure 12: Drought Vulnerability Index for the Study Area

In Laisamis enumeration area, 75.9% of households are Less Vulnerable with an index of between (0.0 to 0.49) and just 1.9 % of the households are Highly Vulnerable. While 22.2 % of the households were Moderately Vulnerable. For Loglogo, 62.2 % of the households were Moderately Vulnerable with an index of between (0.50 to 0.69) with 4.4% being very Highly Vulnerable. 33.3 % households were Less Vulnerable in Log Logo. In Korrr enumeration area, 69.8 % of the households were Less Vulnerable with an index of between (0.0 to 0.49), 28.3 % of households were Moderately Vulnerable while 1.9 % of households were Highly Vulnerable. In Ngurnet enumeration area, 80% of the households were Less Vulnerable with an index of between (0.0 to 0.49), 18.8 % of the households were Moderately Vulnerable. While 1.3 % of the households were Highly Vulnerable (Figure 10).

Figure 13: Vulnerability Index per Enumeration Area

For Laisamis, Korr and Korr the Vulnerability Index was 0.42, 0.45 and 0.42 respectively, which implies that households in the areas are Less Vulnerable. Whereas for Log logo the index is 0.54 implying that it is Moderately Vulnerable. From the above findings it clearly shows that Laisamis Sub-county is less vulnerable with 0.46 Vulnerability Index (Table 3).

The approach used in this study is the integrated vulnerability analysis, which combines both the socio-economic and biophysical factors. This approach includes all the internal state of vulnerability and the external situation. This analytical approach was applied by Madu (2012) in agro-ecological based household vulnerability analysis in Ethiopia and by Deressa et al. (2008) in regionally based vulnerability analysis. This study presents an integrated vulnerability approach to develop vulnerability indices for each household as proposed by Madu (2012) and adopted by Tesso et al. (2012) in Ethiopia

Drought vulnerability is the exposure and sensitivity to environmental (biophysical) forces, various social, cultural, political and economic forces shape by adaptive capacity (Yohe and Tol, 2002; Turner et al., 2003; Skjeflo, 2013). Drought was considered by the respondents as one of the most frequent hazards in the study area. The pastoralist respondents maintained that frequent, prolonged drought events have increased in severity over the past decade or so. This perception corroborate Nicholson's (2014) assertion about drought events in northern Kenya, with rainfall being at least 50% to 75% below normal in almost half of the drought-stricken region and is likely to be linked to changing climatic conditions within the greater Horn of Africa. It is argued that due to the frequency of shocks in the study area, adaptive or coping capacity and mechanisms adopted by vulnerable households could well have equal or larger ranges to that of exposure and sensitivity (Opiyo et al, 2014).

Pastoralists' household's vulnerability to drought in the study area is exacerbated by low adaptive capacity, high drought sensitivity of livelihoods to drought and high exposure to drought to the high aridity. Other factors that contributed to the vulnerability of the households in the study area include high level of employment (54%), lack of formal education among the respondents at 93.8 %, limited access to drought early warning information and livestock extension materials. Households with more members are likely to be more vulnerable than the ones with fewer members. A similar study by Opiyo et al. (2014) had the same observation. The more dependents a household has the more likely for it to be vulnerable since a larger proportion of household resources are directed to dependents who cannot contribute much toward household welfare (Opiyo et al, 2014). This study has shown that female-headed households, household heads with no primary level of education and households headed by divorced and widowed persons, with no access to extension services and early warning information, in particular, are disproportionately likely to be affected by drought related stresses. In times of drought, these categories of households tend to have fewer options. Similarly, female or divorced and widowed household heads are likely not to be empowered enough in pastoral communities to make household decisions (Nabikolo et al, 2012) and are frequently without access to credit services and adequate capital assets or not able to own large herds to manage households' daily requirements. Similar observations have been made by Kakota et al. (2011) in Malawi and Tesso et al. (2012) in Ethiopia that widowed or divorced household heads are more vulnerable because they rely on income earned by either the father or mother as the bread winners. However, studies by Deborah et al. (2019) contradicts these findings and showed that male-headed households were less resilient compared to female-headed households. Studies by Opiyo et al. (2014) and Tesso et al. (2012) found that female-headed households were less resilient largely due to bias in resource allocation and decision making that leans towards males in most pastoral communities. The results and contradicts can be explained by the observation by the IIRR and CTA (2014) which noted that there are emerging trends in pastoralists communities where women are increasingly taking charge of managing livestock enterprises such as poultry, thereby putting them in a position to build their resilience sometimes even better than men. This could also be explained by the fact that our study, Opiyo et al. (2014) and Deborah et al. (2019) were conducted among different ethnic groups including Rendile, Turkana and Pokot also different geographical and socio-economic divergence.

These findings make a strong case for continuous targeting of pastoralist women in resilience-building interventions in the rangelands. The results are consistent with previous findings by Deressa et al. (2008) in similar ecosystems. However, for the biophysical variables, the greater the level of household reliance on natural resources, such as pastoralism or dry land crop farming, the greater will be their vulnerability to climate variability and change. This is partly because the use of such natural resources is dependent on rainfall, which is projected to change. This study observed that almost all the postulated biophysical/environmental variables contribute positively to household vulnerability. It is likely that the level of dependence on natural resources especially pastures and water will vary from household to household. For example, while the majority of households depend on livestock herding as their main source of livelihood, for others, livestock is just an equal or lesser contributor besides other economic activities.

The findings of this study suggest the households in the study area have medium vulnerability Of 0.46 implying that minimum external interventions are necessary due to medium capacity of the households to manage drought. Other studies have indicated that for example in Turkana region, with a similar livelihood pastoral system, has a number of households with high of dependents of famine relief, low engagement in off-farm activities and low levels of education (Blench, 2000; McPeak and Barrett, 2001; Watson and van Binsbergen, 2008). However, for the study area, there is low dependence on external support, while levels of formal education and other non-livestock related income sources are limited.

The determinants of households' vulnerability were found to be significantly influenced by the sex of the household head, age of the household head, size of the household, number of dependents, marital status, social linkages, access to extension services and early warning information. In addition, non-farm income, herd size and diversity, herd

structure and herd mobility, access to markets, households' employment status, coping strategies and access to credit were also observed to be the key determinants of the households' vulnerability to drought. This concurs with studies by Eriksen et al. (2005) and Notenbaert et al. (2013) which similarly observed some of these factors to be the key determinant of households' vulnerability to drought. The results are also consistent with previous findings by Kakota et al. (2011) and Gebrehiwot and van der Veen (2013). From these findings, it seems there is still more to be done to understand vulnerability and its underlying processes.

3.3.2. Relationship between Vulnerability Index and Number of Livestock Owned

Correlations		
		Vulnerability Index
Livestock Unit	Pearson Correlation	-.010
	Sig. (2-tailed)	.851
	N	373

Table 3: Correlation Between Vulnerability Index and Number of Livestock Owned

There is a weak negative ($r = -0.010$, $p = 0.02$) linear relationship between Vulnerability Index and number of livestock owned. The weak relationship may have been weak because there are various other factors contributing to vulnerability. This means that for every increase in the number of livestock owned, there is a decrease in vulnerability index. Livestock is a major livelihood source for pastoralists, hence increase in livestock numbers results in decreased vulnerability to drought.

The study assessed the vulnerability by examining the cattle production as indicated by livestock numbers, as exposed to stressors—here, change in climate—within the time of the study. The study established a weak relationship between vulnerability index and the number of livestock owned by the households. The relationship between vulnerability index and the number of livestock owned is weak and tends towards negative. These findings concur with recent literature by Füssel and Klein (2014) who argued that the vulnerability of a system can be seen as the combination of exposure, sensitivity, and adaptive capacity factors which affect the supposedly inverse linear relationship between the two variables.

This finding resonates with arguments by Bett (2017) that vulnerability brought about by climate variations leads to reductions in livestock productivity by directly depressing animals' adaptive response mechanisms, altering the spread and prevalence of diseases. Similarly, Morignat (2014) adds that increased vulnerability causes social stress and related welfare issues pushing pastoralists to sell off their herds even at prices less than real value. Increased vulnerability, Giridhar (2015) asserts that indirectly compromises the availability of feed crops and quality of forages thus decreasing livestock numbers.

3.3.3. Relationship between Vulnerability Index and Livestock Prices

Correlations		
		Average Livestock Prices
Vulnerability Index	Pearson Correlation	-.006
	Sig. (2-tailed)	.01
	N	373

Table 4: Correlation between Vulnerability Index and Livestock Prices

There is a weak negative ($r = -0.006$, $p = 0.01$) linear relationship between Vulnerability index and prices of the livestock. This means that for every increase in the prices of the livestock, there is a decrease in vulnerability index. Livestock prices contributed minimal to vulnerability because there were various other determinants and factors contributing to the same. Conclusions will be based on the overall contributions of the factors to drought vulnerability.

This finding conforms to the Rosen's hedonic pricing model which is based on the hypothesis that goods are valued based on their attributes as developed by (Rosen, 1974). The findings are consistent with findings elsewhere by Andargachew and Brokken's (1993) study of sheep pricing in highland Ethiopia and Jabbar's (1998) study of small ruminants in southern Nigeria which showed vulnerability caused by climatic changes affect livestock attributes such as condition and size that affect the prices livestock fetch at market. These findings are consistent with findings from elsewhere in the East African ASAL that livestock prices and mortality rates are negatively correlated, implying that prices do not move to stabilize pastoralist incomes in the face of yield shocks. This Coppock (2014) explains the reason for trends in which good rainfall years raise and stabilize livestock prices while drought years lead to low and unstable prices, thereby creating disincentives to reducing herds through sales in times of stress. This helps explain the puzzle of low marketed off-take rates that contribute to pronounced livestock cycles in the study findings.

The consequent result of prolonged high vulnerability index as in case with communities in northern Kenya, was observed by Dawe (2012) to cause imperfect competition depicted by high price elasticity, low expansion of market niches as well as restricted gain between the market players; which eventually results into slow growth of the overall industry. This slow growth due to prolonged vulnerability explains the negative weak relationship between vulnerability and

livestock prices. Semenza and Menne (2009) argued that when prices diminish then the communities' vulnerability index increases as found out in this study.

3.3.4 Relationship between Vulnerability Index and Availability of Pasture (Chi Square Test)

		Vulnerability
Pasture Cover	Pearson Chi-square	24.860
	Asymp. Sig. (2-sided)	0.000
	Cramer's V	0.455
	Df	1
	Cohen's Index(w)	0.455

Table 5: Relationship between Vulnerability Index and Availability of Pasture (Chi Square Test)

The Chi square results indicated that there is a significant relationship between Vulnerability Index and availability of pasture. $\chi^2(1) = 24.860$, $p = 0.000$.

w (Cohen's Index)	
0.00 to 0.30	Small
0.30 to 0.50	Medium
0.5 and above	Large

*Table 6: Reference Values for Interpreting Cohen's Index
(Adapted From Cohen, 1988)*

With reference to Table 9, adopted from Cohen (2013) and as discussed by Gray and Kinnear (2012) it is concluded that the relationship between vulnerability index and availability of pasture in the study area is medium, $w = 0.455$.

The assessment of drought risk and vulnerability applied in this study, has largely reinforced the concept of Wilhite (2014) and Wilhelmi et al. (2012) that drought can be viewed as a product of both the exposure to the climatic hazard (e.g. low in-crop growing rainfall) and the underlying vulnerability of livestock rearing practices, primarily due to low pasture available. The significant relationship between vulnerability index and availability of pasture reinforces findings by Smith (2016) in which he established that lack of pasture will increase vulnerability in four ways: the impact of changes on livestock feed-grain availability and price; the impact on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction. All these events, Smith (2016) linked them to increased community vulnerability especially during drought.

However, Semenza and Menne (2009) established a different reason explaining the relationship between vulnerability index and availability of pasture. In this regard, they indicated that alterations in pasture availability may result in the spread of disease and parasites or produce an increase in the incidence to which a particular disease is already prevalent, which will lead to a decrease in animal productivity and increase in animal mortality thus affecting greatly returns from livestock production. Enclosures to ensure that there is enough livestock feed to last through all seasons, was found that investing in enclosures increased the probability of a household having less drought vulnerability (Deborah et al. 2019). Those least affected by the drought, in terms of cattle lost, were those with large herds who were able to sell some of their cattle and to pay for private access to pastures outside of Maasai areas (Mara et al, 2013). The pastoralist livestock systems common in these areas are highly dependent on natural resources such as pasture, fodder, forest products and water, all of which are directly affected by climate variability (Hourri et al, 2013). People have developed complex strategies such as mobile pastoral systems to access pasture to deal with climate variability and change (Brooks et al. 2009). With poor access to pasture, livestock and the communities become highly vulnerable to drought.

Do you have access to pasture? 1=No access 2=Moderate access 3=Adequate access	Vulnerability Index	Frequencies
2	0.5	379
3	0.3	1
1	0.8	4
Average	0.48	

Table 7: Relationship between Vulnerability Index and Availability of Pasture

3.3.5. Relationship between Vulnerability Index and Number of Water Bodies (Sources)

Correlations		
		Sources of Water
Vulnerability Index	Pearson Correlation	-.256
	Sig. (2-tailed)	.000
	N	362

Table 8: Correlation between Vulnerability Index and Water Bodies

There is a weak negative ($r=-0.256$, $p= 0.00$) linear relationship between Vulnerability index and number of sources of water. This means that for every increase in the number of sources of water, there is a decrease in vulnerability index. The weak relationships may be due to various other factors having significant contribution towards vulnerability. A strong conclusion may not be attainable because water bodies are only one of the various contributors to vulnerability.

3.3.6. Relationship between Vulnerability Index and Livestock Species Diversification (No. Of Livestock Species)

Livestock diversification is one of the key traditional adaptation strategies that have enabled pastoralist communities to survive harsh environmental conditions for centuries (Sperenza, 2010). Diversification of livestock herds has both ecological and economic implications as different livestock species have different water and pasture requirements and react differently to droughts and diseases. Respondents reported that new breeds that are drought tolerance and consumes less pasture now been reared by pastoralists in Marsabit. They reported that new breeds of goats and sheep consume less forage when compared to cattle and they also produce nutritious milk. This is likely to reduce vulnerability at constant population growth rate as observed by (Sperenza, 2010).

Hoffmann (2009) suggested that the use of multi-species and multi-breed herds is one strategy that many traditional livestock farmers use to maintain high diversity in on-farm niches and to buffer against climatic and economic adversities which leads to increased vulnerabilities. The study established that communities in Marsabit County use traditional diversification practices for adaptation to adverse weather conditions and to reduce vulnerability during times of distress. These findings are in line with Seo & Mendelsohn (2008) who modelled that small farms in developing countries were found more climate change resilient due to their more diverse species portfolios, the ease with which they can shift between species and diversify, and their reliance on goats and sheep. On the contrary, commercial dairy and beef operations were more vulnerable than small farms, because their specialized nature makes it difficult for them to switch to other species. The study went further to determine whether there is a relationship between vulnerability index and livestock species diversification and to determine the strength there of for the relationship. The Table 9 shows the results in this regard.

Correlations						
		Cattle	Camels	Goats	Sheep	Donkeys
Vulnerability Index	Pearson Correlation	.017	-.039	-.025	.011	.100
	Sig. (2-tailed)	.747	.459	.632	.840	.059
	N	364	364	364	364	361

Table 9: Correlation between Vulnerability Index and Number of Livestock Species

There is a weak positive ($r=0.017$, $p= 0.747$) linear relationship between Vulnerability index and the number of cattle owned. This means that for every increase in the number of cattle, there is an increase in vulnerability index. Similarly, there is a weak positive ($r=0.100$, $p= 0.059$) linear relationship between Vulnerability index and the number of donkeys owned. This means that for every increase in the number of donkeys, there is an increase in vulnerability index. Also there is a weak positive ($r=0.011$, $p= 0.840$) linear relationship between Vulnerability index and the number of sheep owned. The reason for weak relationship is because of other various factors contributing to drought vulnerability. This means that for every increase in the number of sheep, there is an increase in vulnerability index. On the contrary, there is a weak negative ($r=-0.039$, $p= 0.459$) linear relationship between Vulnerability index and the number of camels owned. This means that for every increase in the number of camels, there is a decrease in vulnerability index. In addition, there is a weak negative ($r=-0.025$, $p= 0.632$) linear relationship between Vulnerability index and the number of goats owned. This means that for every increase in the number of goats, there is a decrease in vulnerability index.

The outcomes of these correlations imply different breed portfolios, as local breeds are more adapted to pastoral systems than others. These findings augment findings in studies by Gouro (2014); Seo & Mendelsohn (2013) in the Sahel who established that species substitution due to climate and vegetation changes occurs during extreme conditions where dromedaries replaced cattle, and goats replaced sheep, following the droughts of the 1980s. A similar study by Gouro (2014) reinforces the current findings in that it established countries such as Niger and Mauritania, and in northern Nigeria where camel rearing is now a common activity as pastoralists sought to lower recurring vulnerabilities during dry

seasons which have become more frequent. Unlike cattle and sheep, which largely feed on herbaceous vegetation, camels browse on shrubs and trees, while goats use both strata. The link between the positive relationship for the camel species is linked to Mendelsohn (2013) finding in which he observed that the use of browsing species has several advantages in that: the browse strata cannot easily be used by other species and tends to offer green forage also during the dry season; and browse is increasing in some environments due to overuse of the herbaceous layer.

4. Summary, Conclusions and Recommendations

4.1. Summary

The magnitude of vulnerabilities to drought in the study area was found to rate at 65.1% for those who were classified as Less Vulnerable with the Vulnerability Index being (0.0 to 0.49). On the other hand, 32.6 % of the households were Moderately Vulnerable with 0.5 - 0.69 Vulnerability Index. Only 2.3% were Highly Vulnerable with Vulnerability Index of 0.7 - 1.0. Various aspects were measured in relation to how they rate at different levels of vulnerability. These aspects included; number of livestock owned, prices of livestock, availability of pasture, number of water bodies and livestock species diversification.

The study established a weak negative ($r=-0.010$, $p=0.02$) linear relationship between vulnerability index and number of livestock owned implicating a decrease in vulnerability as livestock numbers increased. However, the relationship is weak and negative owing to the increase in livestock numbers by a reducing margin as human population owning the livestock increases.

Regarding how vulnerability affects livestock prices, the study established that a weak negative ($r=-0.006$, $p=0.01$) linear relationship between Vulnerability index and prices of the livestock. This implied that at low vulnerability levels, livestock prices were higher. According to this study this negative relationship is due to the fact that goods are valued based on their attributes and vulnerability caused by climatic changes affect livestock attributes such as condition and size that affect the prices.

Effect of availability of pasture on vulnerability was found to be a medium and significant $w=0.455$. This was due to four main factors being: the impact of changes on livestock feed-grain availability and price; the impact on livestock pastures and forage crop production and quality; changes in livestock diseases and pests; and the direct effects of weather and extreme events on animal health, growth and reproduction.

Number of water bodies were found to reduce the vulnerability levels as indicated by a negative relationship ($r=-0.256$, $p=0.00$). The weak negative relationship was due to the fact that most water bodies are developed due to increased vulnerability which brings the aspect of cause and effect. Regarding the relationship between livestock species diversification and vulnerability index, the study found that new breeds that are drought tolerant and consumes less pasture are now being reared by pastoralists in Marsabit. Specifically, new breeds of goats and sheep consume less forage when compared to cattle and also produce nutritious milk are preferred. The study determined that this reduces vulnerability at constant population growth rate. However, the study found that different livestock species had different effect on vulnerability. For instance, cattle numbers indicated as weak positive ($r=0.017$, $p=0.747$) linear relationship with vulnerability index, same as sheep ($r=0.011$, $p=0.840$) and donkeys ($r=0.100$, $p=0.059$). This implied that for every increase in the number of these species, there is an increase in vulnerability index. On the contrary, there is a weak negative ($r=-0.039$, $p=0.459$) linear relationship between Vulnerability index and the number of camels owned same as for goats ($r=-0.025$, $p=0.632$) which meant that for every increase in the number of camels and goats, there is a decrease in vulnerability index.

4.2. Conclusion

The livestock in arid areas of Kenya plays a significant role in the local economies of such areas with many rural Kenyans deriving a range of financial benefits from livestock keeping. Livestock owners often 'cash in' their animals for particular purposes at a time of need and choice which highly determines the levels of vulnerability for such communities. Since pastoralists hold most of their wealth in the form of livestock, the effects of climate change and related challenges affect their entire livelihoods. Given the critical role livestock plays in the lives of the pastoralist communities, there still exists a myriad of constraints emanating from different areas of concern some of which have been highlighted in this study. From the data analysis the following conclusions are deduced.

First, communities will reduce the number of livestock owned at times of high vulnerability. However, the reduction is by a reducing margin as human population owning the livestock increases. Vulnerability also negatively affects livestock prices, making livestock prices fall at times of high vulnerabilities. The negative effect is caused by livestock attributes and vulnerability caused by climatic changes affect livestock attributes such as condition and size that affect the prices.

Secondly, vulnerability is high when there is low availability of pasture which increases stress levels of the communities as livestock is caused by the impact of changes on livestock feed-grain availability and price, the impact on livestock pastures and forage crop production and quality, changes in livestock diseases and pests and the direct effects of weather and extreme events on animal health, growth and reproduction.

Third, number of water bodies was found to reduce the vulnerability levels for communities though by a small margin. The study also concludes that rearing of new breeds that are drought tolerant and consumes less pasture would reduce vulnerabilities for communities in Marsabit County. Key of these species are; camels, donkeys and goats.

4.3. Recommendations

The study has demonstrated that the magnitude of vulnerability to pastoralists to drought is undermined and exacerbated by a number of factors. The research revealed that there are various options to drought adaptation on long - term and short term basis. The research has also identified major impacts of drought on pastoral production systems in Northern Kenya. Based on the study conclusions, a number of recommendations can be suggested as follows: Since women and age groups of 30- 60 years are most active economically, they need to be targeted for development interventions.

- Since households with more household members are shown to be more vulnerable, population control measures through awareness on family planning techniques needs to be enhanced among the households in the study area.
- Rainfall is low and unreliable and even the low rainfall data cannot be obtained due to lack of manned weather stations in the study area. Therefore, we suggest establishment of weather stations at strategic locations in Loglogo, Korr, Laisamis and Ngurur. The weather stations may record rainfall and temperature as a bare minimum.
- Communities are exposed to frequent droughts situations. In order to cope with droughts situations households may keep more drought tolerant livestock like camels and engage in non-drought sensitive livelihoods where possible.
- Exposure to conflict is a major challenge and may result in displacement of populations and stressing the grazing land and water resources. There is need to begin peace building and conflicts resolution mechanism through establishment of peace committees.
- Drought Vulnerability Index for the study area is 0.46 and this suggests Moderate Drought Vulnerability. This result suggests that minimum external resources are required to build drought resilience in the study area in the long term. There is need for capacity building initiatives without undermining the community drought resilience structures.
- As a short-term drought coping strategy, only 7 % came from external sources. 93 % of drought coping strategy originated from within household and community resources. This implies that, external supporters need to provide low inputs and take precautions not to undermine indigenous drought coping mechanism within the community.
- Key factors that contributed to household vulnerabilities include, low access to productive assets, low employment status, poor social networks, low access to extension services, poor access to drought early warning systems, poor remittances from relatives, poor access to credit facilities, low education and literacy levels and poor access to technology. If interventions are made in these key areas, drought resilience may be achieved in the long term.

5. References

- i. Abate, T. (2013). Drought risk and livestock production in Southern Africa. *Journal of Asian Scientific Research*, 2013, 3 (10): 956 -973.
- ii. Abraham, J (2006). Assessing drought impacts and vulnerabilities for long-term planning and mitigation programs. Department of Geography and Regional Development. The University of Arizona, Dec. 6.
- iii. ACTED (2011). Rapid needs assessment in Mandera, Marsabit and Wajir counties. ACTED Assessment Report, Northern Kenya. July - August 2011.
- iv. Ajani, E, N., Mgbenka, R, N., Okeke, M, N (2013). Use of indigenous knowledge as a strategy for climate change adaptation among farmers in Sub-Saharan Africa: Implications for policy. *Asian Journal of Agricultural Extension, Economics and Sociology*. 2 (1): 23-40, 2013, Article no. AJAEES, 2013.
- v. Alam, K (2015). Farmers' adaptation to water scarcity in drought prone environments: A case study of Rajshahi District, Bangladesh. *Agriculture Water Management*. Volume 148, 31 January, pages 196 - 206.
- vi. Andargachew, K. & Brokken's, F. (1993). Intra-annual sheep price patterns and factors under lying price variations in the central highlands of Ethiopia. *International Journal of Agricultural economics* 8(2): 125-138.
- vii. Andreu J., Ferrer-Polo J., Pérez M.A., Solera A., Paredes-Arquiola J. (2013) Drought Planning and Management in the Júcar River Basin, Spain. In: Schwabe K., Albiac J., Connor J., Hassan R., Meza González L. (eds) *Drought in Arid and Semi-Arid Regions*. Springer, Dordrecht pp.237-249.
- viii. Augustine, A., Ayantunde, N., Matthew, D., Turner and Adamou, K. (2015). Participatory analysis of vulnerability to drought in three agro-pastoral communities in the West African Sahel. *Research Policy and Practice* (2015) 5:13.
- ix. ARGOS (2008). Common elements of pastoral farming systems as shown by causal mapping. ARGOS Research Note: Number 43, May.
- x. Barrett, A., Hannan, M., Alam, Z., Pritchard, M (2014). Impact of Chars Livelihood Programme on disaster resilience of Chars communities. Reducing extreme poverty on the Riverine Islands of North West Bangladesh.
- xi. Boko, M. I., Niang, A., Nyong, C., Vogel, A., Githeko, M., Medany, B., Osman-Elesha, R., Tabo & Yanda, P. (2007). *Africa Climate Change Impact 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge U.K, 433 – 467.
- xii. Brooks, N (2003). *Vulnerability, Risk and Adaptation: A concept Framework*. Tyridall Centre. Working Paper 38. September 2003.

- xiii. Baudoin, M., Henly-Shepard, S., Fernando, N., Sitali, Asha., Zommers, Z. (2016). From Top Down to "Community-Centric" approaches to Early Warning Systems Pathways to Improve Disaster Risk Reduction through community participation. *International Journal of Disaster Risk Science*. DoI 10.1007/s 13753-016-0085-6.
- xiv. Brown, J. R.; Kluck, D.; McNutt, C.; Hayes, M (2016). Assessing drought vulnerability using a socio-ecological framework. *Rangelands*. Volume 38, Issue 4, August 2016, pages 162 - 168.
- xv. Bett, D. (2017). The assessment of drought preparedness measures in Kenya. University of Nairobi.
- xvi. Catley, C., Lind, J., Scoons, I. (2013). Pastoralism and Development in Africa: Dynamic change and the margins. *Research, policy and practice* 2013, 3:19.
- xvii. Christiansen, L.J., & Subbarao, K. (2001). Towards an understanding of vulnerability in rural Kenya.
- xviii. Climate and Development Knowledge Network (2012). Managing climate extremes and disasters in the agriculture sector. Lessons from the IPCC SREX report.
- xix. Cordaid, (2007). Building resilience to climate change. Experiences of Kenyan pastoralist communities in managing drought; Nairobi, Kenya.
- xx. Colorado Water Conservation Board (2013). Drought Vulnerability Assessment Technical Information. Disaster Mitigation Act 2000 and Section 409, PL-93-288.
- xxi. Cohen, V. (2013) Adaptive mechanisms and genomic plasticity for drought tolerance for pastoral Communities.
- xxii. Coppock, B. (2014) Increasing flexibility in rangeland management during drought. *Ecosphere Journal Review*.
- xxiii. Delf University (1993). Global Vulnerability Assessment. A global Vulnerability Assessment for populations, coastal wetlands and rice production on global scale. Delft Hydraulics, The Netherlands. Second Edition.
- xxiv. Deka, S., Glakas, C., Olivier, M (2011). Vulnerability to Climate Change: Assessing Climate Vulnerability in North Africa; A student working paper no. 3, CCAPS, USA.
- xxv. Development Initiatives (2017). Assessment of Kenya's preparedness to disasters caused by natural hazards: Floods, drought and disease outbreak Report.
- xxvi. Dima, J (2011). Assessment of pastoral resource management risks and conflicts among the Waso Boran of Northern Kenya. Ph. D Thesis, Egerton University, Njoro, Kenya.
- xxvii. Dhanapal, G (2014). Climate Change Vulnerability Assessment, Gaps and Challenges.
- xxviii. Economic and Political Weekly. June 2014.
- xxix. Doll, P (2009). Vulnerability to the impact of climate change on renewable groundwater resources: a global-scale assessment. *Environment Research Letters* (2009) 035006 (12pp). Institute of Physical Geography, Goethe University Frankfurt, Frankfurt am Main, Germany.
- xxx. Davies, W. (2014) Does Breed Matter to Cattle Farmers and Buyers? Evidence from West Africa?", *Ecological Economics*
- xxxi. Delpla, J. (2011) The impact of drain blocking on an upland blanket bog during storm and drought events, and the importance of sampling-scale. *Journal of Hydrology* volume 404, issues 3 – 4.
- xxxii. Elliot, F (2004). Atrial pastoralists of Kenya: Studying pastoralism, drought and development in Africa's Arid and Semi-Arid Lands. Cultural survival studies in Ethnicity and change series. Order number, 0 - 205-26997-4.
- xxxiii. Erian, W (2010). Drought vulnerability in the Arab Region: A case study - Drought in Syria. Ten years of scarce water - 2000 - 2010.
- xxxiv. Fan, M., Zhang, C., Li, W (2013). Adaptation of herders to droughts and privatisation of rangeland use rights in arid Alxa Left Banner of Inner Mongolia. *Journal of Environment Management*. Volume 126: 182 - 90. Doi:/10.1016/j.jenvman. 2013.4.053.
- xxxv. Fussel, H.M. & Klein, R.J.T. (2014) Assessing vulnerability and adaptation to climate change: An evolution of conceptual thinking. In Proceeding of the UNDP Expert Group Meeting on Integrating Disaster Reduction and Adaptation to Climate Change, Havana, Cuba.
- xxxvi. Fratkin, E.M. and College, S (2004). Atrial pastoralists of Kenya. Studying pastoralism, drought and development in Africa's Arid Lands. Pearson Education Inc. 2 nd Edition No. 0 - 205-26997-4.
- xxxvii. Ford, J. D., Goldhar, C. (2012). Climate change vulnerability and adaptation in resource dependent communities: a case study from West Greenland, Canada. Vol.54: 181 - 196, 2012.
- xxxviii. Fussel, H.M. (2005). Vulnerability in Climate Change Research: A Comprehensive Conceptual Framework. Breslauer Symposium, University of California International and Area studies, UC Bekeley.
- xxxix. Fussel, H.M., and Klein, R.J. (2006). Climate Change Vulnerability Assessment: An evolution of conceptual thinking. *Climate Change* 75: 301- 329.
- xl. Gonzalez-Velosa (2012) "Choice of Functional Form for Hedonic Price Equations", *Journal of Urban Economics* volume 10, issue 1.
- xli. Gouro, M. (2014) A decision support system for drinking water production integrating health risks assessment. Center for Socio-Economic Documents: Tehran, Iran
- xlii. Gray, C. & Kinneer, D. (2012) "Livestock Marketing, Food Security and Related Issues in Ethiopia", Addis Ababa, Ethiopia.
- xliii. Gesare, H.M. (2012). Assessment of climate change impacts on natural resources and the different gender among pastoral communities in Samburu, Kenya. M.Sc thesis, School of Environmental Studies, Kenyatta University, Kenya.

- xliv. Graciela, M., Adrea, S., and Jason, S., (2014). Climate change vulnerability, impact and adaptation assessment. *International Journal of Climate Change Strategies and Management*, Vol.6 Iss. 4 pp. 442 - 476.
- xl. Goldman, M., Riosmena, F (2013). Adaptive capacity in Tanzania Maasailand: Chnaging strategies to cope with drought in fragmented landscapes. Vol. 23, Issue 3, June 2013, pp. 588 - 597.
- xlvi. GOK (2005). Draft National Disaster Management Policy for Sustained Development of Arid and Semi-Arid Lands (ASALS) of Kenya. Ministry of State for Special Programmes, Office of the President.
- xlvii. GOK (2008). Review and analysis of existing drought risk reduction policies and programmes in Kenya. National report on drought risk reduction policies and programmes. Ministry of state for special programmes, Office of the President.
- xlvi. GOK (2010). National Climate Change Response Strategy; Government of Kenya, Nairobi.
- xl. GOK (2014). National Climate Change Framework Policy, Government of Kenya, Ministry of Environment and Natural Resources, Nairobi.
- I. GIZ (2015). The Vulnerability Sourcebook. Concepts and guidelines for standardised vulnerability assessments. Federal Ministry of Economic Cooperation and Development.
- li. Gleick, P.H (2014). Water, drought, climate change and conflict in Syria. *Weather, Climate and Society*. Volume 6. page 331-340. Doi: 10.1175/twcas-D-13-000591.
- lii. Hulufu, H (2011). Cross border planning improves pastoralist resilience to drought in Kenya and Ethiopia. *Disaster risk reduction in the drylands of the Horn of Africa*.
- liii. Hoffmann, L. (2009) Drought discourse and vulnerability. In *Drought: A Global Assessment, Natural Hazards and Disasters Series*; Routledge Publishers: London, UK.
- liv. ISDR (2012). Disaster Reduction in Africa. *Africa Informs*; Special Issue on Drought Risk Reduction.
- lv. IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Retrieved from http://ipcc_wg2.gov/ar5/report/final-draft.
- lvi. Jabbar, M.A. (1998) "Livestock Marketing, Food Security and Related Issues in Ethiopia", Addis Ababa, Ethiopia.
- lvii. Kaufmann, B., Nelson, W., Gudere, R., Canger, V., Golicha, D., Frank, M., Roba, H., Mwai, O., and Hulsebusch, C. (2012). Identifying Local Innovations in Pastoral areas in Marsabit County, Kenya, DITSL, University of Kassel, Germany.
- lviii. Kaufmann, B; Kratli, S; Hulsebusch, C; Brooks, S (2013). Pastoralism: A critical asset for food security under global climate change. *Animal Frontiers*. Vol. 3. No.1.
- lix. Kelly, P., and Adger, W. N. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climate Change* 47: 325-352.
- lx. Kemal, F., Nmez, S., Ali, U., Mran, K., Scu, M., Ayan, E., Ertan, T. (2005). An Analysis of Spatial and Temporal Dimension of Drought Vulnerability in Turkey Using the Standardized Precipitation Index. *Natural Hazards* (2005) 35: 243–264.
- lxi. Kellner, O., Niyogi, D. (2014). Forages and pasture symposium: Assessing drought vulnerability of agricultural production system in the context of the 2012 drought. *Journal of Animal Science*. Volume 92, Issue 7, 1 July 2014, pages 2811- 2822.
- lxii. Khajuria, A. and Ravindranath, N.H (2012). Climate Change Vulnerability Assessment: Approaches DPSIR Framework and Vulnerability Index. *Journal of Earth Science and Climate Change*, 3:1.
- lxiii. Kabubo-Mariara, F. (2011) "Heteroscedastic Hedonic Price Model for Cattle in the Rural Markets of Central Ethiopia", *Applied Economics*. Volume 43, Issue 24.
- lxiv. Kwadwo, A. (2012) Climate risk management information, sources and responses in a pastoral region in East Africa. *Climate Risk Management Journal*. Volume 11, pages 1- 14.
- lxv. Korb, K.A. (2013). Conducting Educational Research: Step 6 – Select sampling technique. Retrieved from www.koebedpsych.com.
- lxvi. Lekapana, P. L (2013). Socioeconomic impacts of drought on pastoralists, their coping strategies, and government interventions in Marsabit County, Kenya. M.A. Thesis. Centre for Advanced Studies in Environmental Law (CASELAP), University of Nairobi, August 2013.
- lxvii. Liu, X., Wang, Y., Peng, J., Brainoh, A, K., Yin, H (2013). Assessing vulnerability to drought based on exposure, sensitivity and adaptive capacity: A case study in middle Inner Mongolia of China. *Chinese Geographical Science*. Volume 23, Issue 1, pp. 13 - 25.
- lxviii. Martin, R., Linstadler, A., Frank, K., Muller, B. (2014). Livelihoods security in the face of drought - assessing the vulnerability of pastoral households. *Environmental Modeling and Software Society*, Leipzig, Germany.
- lxix. Manger, L., and Ahmed, A.G.M (2000). Pastoralists and environment. Experiences from the Greater Horn of Africa. *Proceedings of the regional workshops on African drylands*, Addis Abeba and Jinja. OSSREA, Addis Abeba.
- lxx. McCarthy, J.J. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of IPCC. Cambridge University Press, Cambridge, United Kingdom.
- lxxi. Miller, S., Yoon, S. W., Yu, B. (2013). Vulnerability indicators of Adaptation to Climate Change and Policy Implications for IDB Projects. Policy Brief No. IDB-PB-184.
- lxxii. MRC (2010). Review of climate change adaptation methods and tools. MRC Technical Paper No. 34.
- lxxiii. Mude, A (2009). Index Based Livestock Insurance for Northern Kenya's Arid and Semi-Arid Lands. The Marsabit Pilot Project Report. ILRI January 2009.

- lxxiv. Miyan, M. A (2014). Droughts in Asian Least Developed Countries: Vulnerability and Sustainability. *Weather and Climate Extremes*. Vol.7 (2014) pp. 8 - 23.
- lxxv. Mutu, P. L., Akwee, P. E., Wakhungu J. W (2017). Environmental drought effects on human vulnerability to the Turkana Nomadic pastoral population of Elemi Triangle region, Turkana County, Kenya. *International Journal of innovation and research and advanced studies*. Volume 4, Issue 11, November, 2017. ISSN: 2394-4404.
- lxxvi. Murdoch, P.S.; Baron, J.S.; Miller, T.L (2010) Potential effects of climate change on surface water quality in North America. *Water Resources Journal*. Volume 28, pp 67 – 82.
- lxxvii. Notenbaert (2012) Dynamic effects of drought on U.S. Crop and livestock sectors. *International Journal of Agriculture*. Volume 47, Issue 2, pp. 261 – 284.
- lxxviii. NDMA (2018). Marsabit County Drought Early Warning Bulletin. June, 2018.
- lxxix. Ngugi, R.K.; Nyariki, D.M. (2002). A review of African pastoral production systems: Approach to their understanding and development. *Journal of Human Ecology*. 13(3): 237-250.
- lxxx. Njoroge, B.N. (2010). Environmental and Social Impact Assessment (ESIA) Report for the proposed strengthening of Laisamis-South Horr - Loiyangalani Road. Vol IV. Lake Turkana Wind Power Limited.
- lxxxi. Nkomo, J.C., Nyong, A.O. and Kulindwa, K. (2006). The impacts of climate change in Africa. The stern review on the economics of climate change.
- lxxxii. Nkomo, J. C. (2006). The impacts of climate change in Africa, Ph.D Thesis, University of Cape Town, South Africa.
- lxxxiii. Newsham, A., Naess, L.O. and Guthiga, P. (2011). Farmers' knowledge and Climate Change Adaptation: Insights from policy processes in Kenya and Namibia. Policy Brief 042.
- lxxxiv. Oba, G., and Lusigi, W. (1987). An overview of drought strategies and land use in African pastoral systems; Kenya Arid Lands Research Station, Marsabit, Kenya.
- lxxxv. ODI (2010). Pastoralism demographics, settlement and service provision in the Horn and East Africa. Transformation and opportunities. Regional Pastoral livelihoods and advocacy project.
- lxxxvi. Ogwel, L (2011). The drought crisis in Kenya - will it ever end? Disaster risk reduction in the drylands of the Horn of Africa. Good practice examples from the ECHO drought cycle management partners and beyond.
- lxxxvii. Oshita, G. (2010) Impacts of climate change on livestock husbandry and adaptation options in the arid Sahel belt of West Africa: Evidence from a baseline survey.
- lxxxviii. Omondi, P. A., Awange, L. J., Farootan, E., Ogollia, L. A. (2013). Changes in temperature and precipitation extremes over the Greater Horn of Africa from 1961 to 2010. *International Journal of Climatology*. DOI. 10. 1002/JOC.3763
- lxxxix. Osano, P. M., Said, M. Y., Leeuw, J., Moiko, S.S., Kaelo, D.O., Schomers, S., Birner, R., Ogutu, J.O (2013). Pastoralism and Ecosystem-based adaptation in Kenyan Masailand. *International Journal of Climate Change Strategies and Management*. Vol. 5. No. 2, 2013, pp. 198 - 214.
- xc. Opiyo et al (2014). Measuring household vulnerability to climate-induced stresses in pastoral rangelands of Kenya: Implications for resilience programming. *Pastoralism: Research, Policy and Practice* 2014, 4:10.
- xc. Opiyo, F., Wasongo, O., Nyangito, M., Schilling, J. and Munang, R. (2015). Drought
- xcii. Adaptation and Coping Strategies Among the Turkana Pastoralists of Northern Kenya.
- xciii. *Int J Disaster Risk Sci* (2015) 6:295–309.
- xciv. PACIDA (2009). Drought situation report for Marsabit, Chalbi and Laisamis Districts, Northern Kenya. Development partners drought response action.
- xcv. Parannello, S. (2009). Pastoralists' vulnerability in the Horn of Africa: Exploring political marginalisation, donors' policies and cross-border issues. Humanitarian Policy Group, ODI, London, UK.
- xcvi. Paarlberg & Lee (2016) "Risk and Social Change in an African Rural Economy: Livelihoods in Pastoralist Communities." Routledge.
- xcvii. Presser, S. and Krosnick, J.A. (2010). Question and Questionnaire Design. *Handbook of Survey Research*, Second Edition.
- xcviii. Scoones (2012) Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather Climate Extremes Assessment Report*.
- xcix. Seo and Mendelsohn, (2016). An analysis of African livestock management by agro-ecological zones. *BE J. Econ. Anal. Policy*
- c. Sivakumar, Mannava V.K., Raymond P. Motha, Donald A. Wilhite, and John J. Qu (Eds.). 2011. Towards a Compendium on National Drought Policy. Proceedings of an Expert Meeting on the Preparation of a Compendium on National Drought Policy, July 14-15, 2011, Washington DC, USA: Geneva, Switzerland: World Meteorological Organization. AGM-12; WAOB-2011. 135 pp.
- ci. Smith (2016) Climate change, drought and desertification. *Journal of Arid Environments* 34: 133-140.
- cii. Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasana, B., Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihoods resilience in Sub-Saharan Africa: Technological, Institutional and Policy Options. *Weather and Climate Extremes*. Vol. 3 (2014) pp. 67 - 79.
- ciii. Schroter, D., Polsky, C., & Patt, A.G. (2004). Assessing Vulnerabilities to the effects of global change: An eight step approach; *Mitigation and Adaptation Strategies for Global Change* (2005) 10: 573-596.
- civ. Schilling, J. and Remling, E. (2011). Local adaptation and national Climate Change policy in Kenya: Discrepancies, options, and the way forward. Research Group Climate Change, Institute for Geography, Hamburg University, Grindelberg, Germany.

- cv. Smith, S. (2013). Determining sample size: How to ensure you get the correct sample-size. Insights, April 08. Retrieved from www.qualtrics.com/blog/determining-sample-size.
- cvi. Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16 (2006) 282 – 292.
- cvi. Sun, X (2005). Dynamics of continuity and change in pastoral subsistence among the Rendille in Northern Kenya: With special reference to livestock management and response to socio-economic change. Graduate School of Asian and African Studies, Kyoto University. Africa Study Monograph. Suppl. 31:1 -94.
- cvi. Sperenza, M. (2010) A new approach for predicting drought-related vegetation stress: integrating satellite, climate and biophysical data over the US central plains. *ISPRS J Photogramm Remote Sens.* 2015;59(4):244–53. Cross Ref Google Scholar.
- cix. Spies (2011). Establishing indices of genetic merit using hedonic pricing: an application to dairy bulls in Alberta. *Canadian journal of Agricultural Economics*. Volume 47, Issue 2, pp 261 -284.
- cx. Taylor, R.; Scanlon, B.; Döll, P.; Rodell, M.; van Beek, R.; Wada, Y.; Longuevergne, L.; Leblanc, M.; Famiglietti, J.; Edmunds, M.; et al. Ground water and climate change. *Nat. Clim. Chang.* 2013, 3, 322–329.
- cx. Thomas, J., Wheeler, T.R.; Reynolds, C. (2014) Predicting the risks from climate change to forage and crop production for animal feed. *Anim. Front.* 2013, 1, 36–41.
- cxii. Thornton P.K., van de Steer, J., Notenbaert, A. and Herrero, M. (2009): The impacts of climate change on livestock and livestock systems in developing countries.
- cxiii. Thornton P.K., Jones P.G., Owiyo T., Kruska R.L., Herrero M., Kristjanson P., Notenbaert A., Bekele N. and Omolo A.(2013):Mapping climate vulnerability and poverty in Africa. Report to the Department for International Development, ILRI, Kenya. pp 171.
- cxiv. Tambo, J. A. and Abdoulaye, T (2013). Smallholder farmers' perception of and adaptations to climate change in Nigerian Savanna. *Regional Environmental Change*. Vol. 13, Issue 2, pp. 375 - 388.
- cxv. Thomalla, F., Downing, T., Spanger-Siegfried., Han, G., Rockstrom, J. (2006). Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters*, 2006, 30(1): 39 - 48.
- cxvi. UNCCD (2015). Capacity development to support National Drought Management Policies. Regional Coordination Unit, UNCCD, Africa Region, Accra, Ghana.
- cxvii. UNDP (2007). The global drylands imperative. Implementing Millennium Development Goals in the drylands of the world. Nairobi, Kenya.
- cxviii. UNDP (2009). Improving market access to dryland commodities in East Africa. Synthesis Report.
- cxix. Yehong, S., Hongjian, Z., Lingyun, Z., Qingwen, M., Weixia, Yin (2017). Adapting to droughts in Yuanyang Terrace of SW China: insight from disaster risk reduction. *Mitigation and Adaptation Strategic for global change*, 2017, Vol. 18, Issue 6, 759 - 771.
- cxx. Willinges, K., Mechler, R., Bowyer, P., Balkovic, J (2017). Towards and assessment of adaptive capacity of the European Agriculture Sector to droughts. *Climate Services*. Volume 7, August, 2017, pp. 47 - 63.
- cxxi. Wekesa, M. (2006). Drought, Livestock and Livelihoods: Lessons from 1999 - 2001 emergency response in Kenya. A consultancy report for Ministry of State for Special Programmes. Office of the President.
- cxxii. Western, D. and Nightingale, D. (2004). Environmental change and vulnerability of pastoralists to drought. A case study of the Masai in Amboseli, Kenya. Chapter 3, *The African Environment Outlook Report*.
- cxxiv. Wilhite, A.D. and Glantz, M. H. (1985). Understanding drought phenomenon: The role of definitions. *Water International*. 10 (3) 1985, pp. 111 - 120.
- cxxv. Waggoner, P.; Revelle, R. Summary (2010). In *Climate Change and U.S. Water Resources*; Waggoner, P.E., Ed.; John Wiley and Sons: Toronto, ON, Canada, 2010.
- cxxvi. Whitehead, P.G.; Wilby, R.L.; Battarbee, R.W.; Kernan, M.; Wade, A.J. (2011) A review of the potential impacts of climate change on surface water quality. *Hydrol. Sci. J.* 2011, 54, 101–123. [CrossRef]
- cxxvii. Wilhite DA, Svoboda MD, Hayes MJ. Understanding the complex impacts of drought: a key to enhancing drought mitigation and preparedness. *Water Resour Manag.* 2007;21(5):763–74. doi: 10.1007/s11269-006-0976-5.CrossRefGoogle Scholar
- cxxviii. Wilson, Sam. 2017. "12% of Montana is in exceptional drought—a once-in-century event, NOAA scientist says." *Billings Gazette*. August 1, 2017.
- cxxix. Zarafshani, K., Sharafi, L., Azadi, H., Hosseininia, G.H., De Maeyer, P., Witlox, F. (2012). Drought Vulnerability Assessment: The Case of Wheat Farmers in Western Iran. *Global and Planetary Change*, vol. 98-99 (2012), 122-130.
- cxxx. Zewdu, A. and Jalleta, T. (2011). Using a crisis modifier and contingency planning to respond rapidly to drought emergencies. *Disaster risk reduction in the drylands of the Horn of Africa*.