International Scholars Journals

African Journal of Geography and Regional Planning ISSN 3627-8945 Vol. 6 (11), pp. 001-009, November, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Drought severity and their effects on rural livelihoods in Laikipia district, Kenya

Julius Mburu Huho[1*], Josephine K. W. Ngaira[1] and Harun O. Ogindo[2]

[1]Department of Geography, Maseno University, P. O. Box 333 Maseno - Kenya.

[2]Department of Botany and Horticulture, Maseno University, P. O. Box 333 Maseno - Kenya.

Accepted 18 May, 2019

Over 80% of Kenya land mass fall under arid and semi arid lands (ASAL), which are prone to frequent droughts. About one third of Kenya's population lives in the ASAL and largely depends on rain-fed agriculture as their source of livelihoods. However, most of the agricultural activities are constrained by recurrent droughts. To analyse the effects of droughts on rural livelihoods, this study was carried out in the semi arid Central and Mukogodo divisions of Laikipia district, Kenya for the period between 1975 and 2008. Standardized precipitation index was used to quantify drought severity. Rural livelihood data was obtained through interviews and questionnaires. Correlation coefficient was used to test the association between drought severity and crop production and livestock losses. Four categories of drought namely mild, moderate, severe and extreme droughts were identified. Over 70% of the droughts in the study area occurred in runs. The study established that as drought increased in severity more rural livelihood were disrupted causing high dependency of relief aid. As a result, farmers ventured into charcoal burning, illegal logging and sand harvesting as alternative livelihoods sources exacerbating desertification. The study concludes that farmers' resilience to drought lessens with increase drought severity.

Key words: Kenya, Laikipia district, drought severity index, droughts, rural livelihoods.

INTRODUCTION

Drought is a form of environmental stress that originates from a deficiency in precipitation over an extended period of time long enough to cause moisture deficiency, biotic loss, crop failure, loss of lives both human and bovine and general hardships (Ngaira, 2004) . Droughts have direct and indirect effects on livelihoods especially where they are weather dependent. The term livelihood is de-fined as a means of living, especially of earning enough money to feed oneself. In Africa, rural livelihoods are largely derived from rain-fed agriculture with about 70% of the continent's population depending on agriculture for their livelihood (Muthui, 2009). In Kenya over 80 percent of the population earns their living through farming and employment in agricultural sector (Mose, 1999). Nonetheless, increasing rainfall variability and frequent extreme climatic events especially droughts and floods disrupt agricultural production leading to famine and severe loss of livelihoods. Prolonged dry years have reduced the ability of African societies to cope with droughts (Muthui, 2009). Kenya has a tropical climate with two rainy seasons, one occurring in March, April and May and the second one in October, November and December. It is divided into seven agro-climatic zones (AEZ) ranging from humid climates, in AEZ I, that receive annual rainfall of above 1100 mm to the very arid climates, in AEZ VII, with annual rainfall that is less than 300 mm (Awuor, 1997). Over 80 percent of the country falls under arid and semi arid lands (ASAL) which are prone to droughts.

In Laikipia District, agriculture employs over 80 percent of its population (Flury, 1987; Kairu, 2002). The main agricultural activities include: commercial ranching, pas-toralism and marginal mixed farming. In Central Division of Laikipia District, the source of rural livelihood was marginal mixed farming which was largely practiced by Kikuyu community. The types of livestock kept were cattle, shoats and chicken while crops grown were largely

*Corresponding author. E-mail: jhuho2003@yahoo.com, jmhuho@gmail.com.

Table 1. Recent droughts in Kenya and number of people affected.

Year	Number of people affected
1975	16,000
1977	20,000
1980	40,000
1984	200,000
1992	1,500,000,000
1995 - 1996	1,400,000,000
1999 - 2000	4, 400,000,000
2004 - 2006	3,500,000,000

Source: Oxfam (2006); Ngaira (2004).

maize, beans and potatoes. Some farmers grew sweet potato vines, as human food and fodder for shoats, and some horticultural crops. Livestock were kept not only as insurance against drought but also to provide manure for the crops. In Mukogodo Division farmers earned their livelihood through pastoralism. They kept cattle and shoats. Very few farmers owned camels. Over 90 percent of the division's inhabitants were the Maasai. Nevertheless, drought was the major constraint in all agricultural activities in the study area (Kairu, 2002).

Recent droughts in Kenya

Reduction in agricultural production in Kenya has been witnessed disrupting rural livelihoods. For example maize, which is the staple food in Kenya and grown by up to 90% of rural households declined in yields from 2.7 million tonnes in 1995 to 2.1 million tonnes in 2007 and 30% reduction in annual yields over the same period of time (JesuitHakimani, 2009). Decline in maize production was largely as a result of moderate to severe droughts which occurred in 1995 - 1996, 1999 - 2000 and 2004 - 2006. According to Centre for Governance and Development (2005), the national maize yield per acre dropped from 1.84 tonnes during the 1986 - 1990 periods to 1.71 tonnes during the 1991 - 1995 periods. It fell further to 1.58 tonnes during the 1996 - 2003 periods. The decline in maize production was attributed to changes in weather patterns and other factors such as politics and escalating cost of production. Two major drought events, the 1995 - 1996 and 1999 - 2000, were associated with decline in maize yields. On average, annual rainfall totals during these periods were between approximately 19 and 40 percent below the national rainfall average of 621 mm causing moderate to severe droughts that affected maize production. Ongwae and Karanja (2005) and Ngaira (2004) state that more than 70% of natural disasters in Kenya are related to extreme climate variations. Over the recent past, droughts have become a regular phenomenon with the number of affected people increasing.

Table 1 shows recent drought incidences in Kenya and the number of people affected.

Study area

Laikipia District is located on the equator in central regions of Kenya. It lies between 36°10" and 37°24" East and latitudes 0°17" South and 0°45" North and covers an area of 9,723 square kilometers. The district lies in the semi arid areas (AEZ V) of Kenya and has annual rainfall that varies between 400 and 750 mm and is classified as 50 - 85% ASAL (GoK, 2002). The study was carried out in the semi arid Central and Mukogodo Divisions of Laikipia District, Kenya. The two divisions lie between longitudes 36° 34" and 37° 24" East and latitudes 0° 2" South and 0° 33" North (Figure 1). The study area is located in the rain shadow of Mount Kenya making the area dry. Rainfall follows the seasonal movements of the Inter Tropical Convergence Zone (ITCZ) resulting in two rainfall seasons, the long rains that occur in March, April and May season and the short rains that occur in October, November and December season. Rainfall is generally low with mean annual rainfall of 636.6 and 507.8 mm in Central and Mukogodo Divisions respectively. Small-scale rain-fed mixed farming was largely practiced in Central Division while pastoralism was the main source of livelihood in Mukogodo Division, which is predominantly a rangeland (Kairu, 2002).

Objectives of the study

The objectives of the study were to:

(i) Analyze drought characteristics in Central and Mukogodo Divisions of Laikipia District between 1975 and 2008.
(ii) Examine the effects of drought on rural livelihoods in eastern parts of Laikipia District (Central and Mukogodo Divisions).

METHODOLOGY

Data for the study was collected in Central and Mukogodo Divisions, which formed the eastern part of Laikipia District. A period of 34 years was considered in the analysis, that is, the period between 1975 and 2008. Rainfall data for the period was obtained from Laikipia airbase meteorological station for Central division and Mpala research station for Mukogodo division and was used in the analysis of drought characteristics. The divisions' livelihood data was obtained from subsistence farmers through the use structured interviews. A total of 383 subsistence farmers were interviewed. Two types of livelihoods were considered in the study: crop faming (specifically, maize and bean production) in Central division and pastoralism (cattle, sheep and goats) in Mukogodo division. Questionnaires were administered to agricultural extension officers who provided divisional livestock loss and crop yields estimates. Standardized precipitation index (SPI) was used in the analysis of drought severity. The SPI has been used in to analysis drought severity in Australia (Abawi et al., 2003), in Karnataka, India (Sharma et al., 2009), in the Mexico (Giddings et al., 2005) and in Iran (Akhtari et al., 2008) among other regions of the world. The SPI is calculated as follows:

$$SPI = \frac{x^{=} - x}{\sigma}$$

Where: σ = Standard deviation

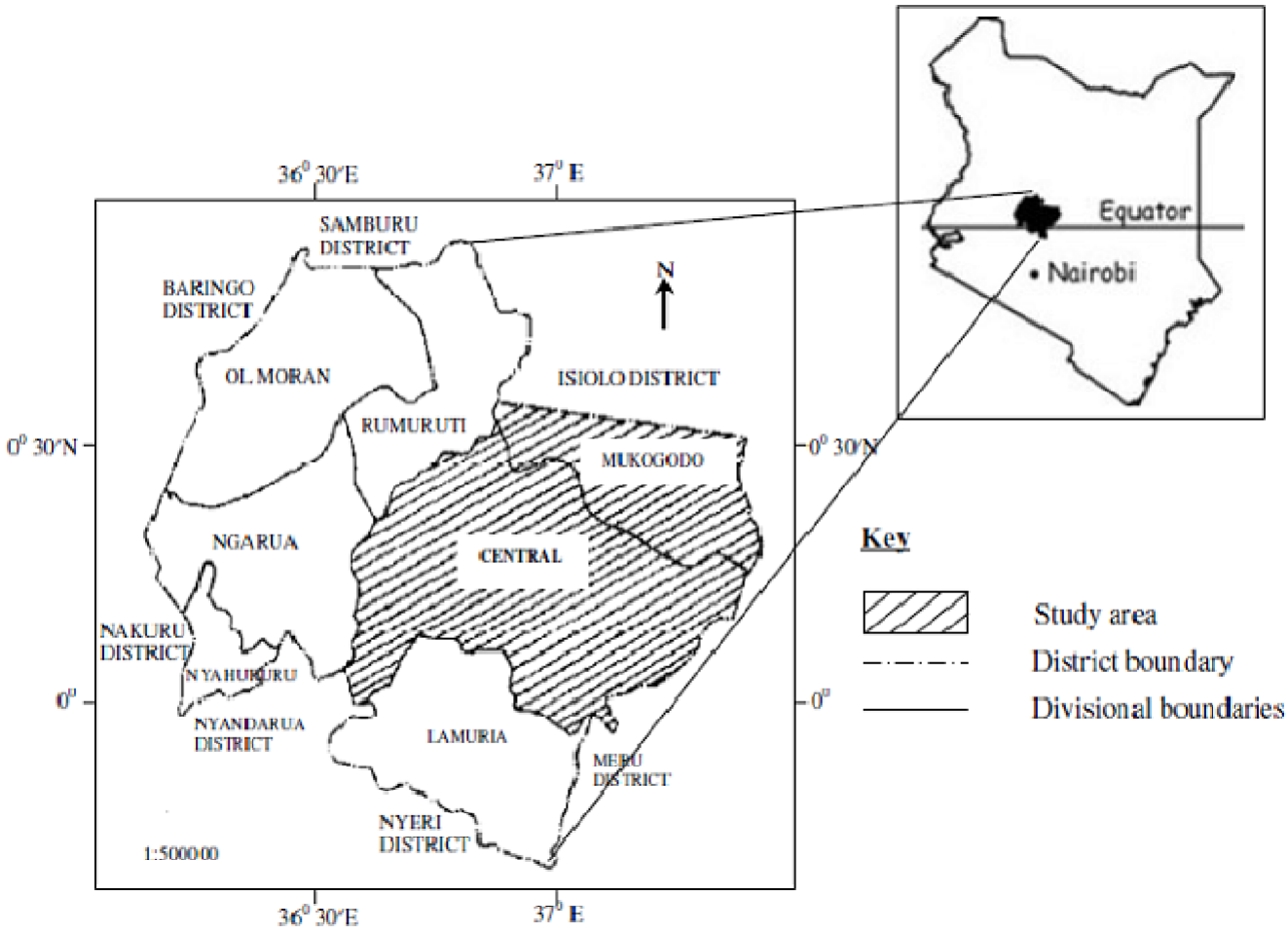

Figure 1. Location of Laikipia district.

$\bar{x}$ = Precipitation

$\overline{x}$ = Mean precipitation.

The study area had normal or mean precipitation when SPI was zero (0.00). Positive SPI values indicated greater than mean precipitation (above normal) while negative values indicated less than mean precipitation (below normal). A drought was considered to have occurred when the SPI value was negative and ended when the value became positive. In the study droughts were categorized as mild when the SPI value ranged from 0 to -0.99; moderate when the value ranged from -1.0 to -1.49; severe when the value ranged from -1.5 to -1.99 and extreme when the value ranged from was -2.00 and below. Pearson product correlation coefficient (*r*) was used to establish the relationship between drought severity and crop production or livestock loss.

RESULTS

Drought characteristics

Droughts in the study area occurred when annual rainfall fell below the long-term mean, that is, below 628.3 mm and 507.8 mm in Central and Mukogodo divisions respectively giving rise to negative SPI values. About 47.1 and 52.9% of the 34 years studied, (1975 - 2008) had droughts in Central and Mukogodo division respectively. Four drought severity categories were identified. These were mild, moderate, severe and extreme (Table 2).

Central division had mild droughts in 1982, 1983, 1985, 1987, 1988, 1991, 1992, 1994, 1996 and 2008. These droughts had their severity ranging between -0.20 and -0.87. Moderate droughts occurred in 1993 (-1.15), 1999 (-1.04) and 2006 (-1.00). Three severe drought events were experienced in 1980 (-1.86), 1984 (-1.75) and 2000 (-1.93). Mukogodo division had mild droughts occurring in 1982, 1983, 1985, 1992, 1993, 1994, 1995, 1999, 2002, 2005, 2006 and 2008. The severity index of these droughts ranged between -0.03 and -0.98. Moderate droughts occurred in 1976 (-1.35), 1980 (-1.39) and 2006 (-1.29). Severe droughts occurred in 1991 (-1.93) while extreme droughts occurred in 1984 (-2.10), 1996 (-2.13) and 2000 (-2.11) (Table 2).

Over 70% of all the droughts in the study area occurred

Table 2. Drought severity in central and Mukogodo divisions (1975 - 2008).

Central division				Mukogodo division			
Mean annual rainfall 636.6 mm				Mean annual rainfall 507.8 mm			
Year	Annual rainfall total (mm)	Drought severity index (SPI)	Drought category	Year	Annual rainfall total (mm)	Drought severity index (SPI)	Drought category
1982	571.8	-0.32	Mild	1982	476.6	-0.21	Mild
1983	579.8	-0.27	Mild	1983	466.8	-0.27	Mild
1985	481	-0.83	Mild	1985	448.1	-0.39	Mild
1987	505.9	-0.69	Mild	1992	360.7	-0.97	Mild
1988	495.6	-0.75	Mild	1993	359.4	-0.98	Mild
1991	519.2	-0.62	Mild	1994	502.9	-0.03	Mild
1992	600.5	-0.16	Mild	1995	439.4	-0.45	Mild
1994	601.5	-0.15	Mild	1999	443	-0.43	Mild
1996	562.2	-0.37	Mild	2002	420.2	-0.58	Mild
2008	474.5	-0.87	Mild	2005	389.3	-0.78	Mild
1993	425.4	-1.15	Moderate	2008	450.4	-0.38	Mild
1999	453.8	-1.04	Moderate	1976	302.3	-1.35	Moderate
2006	455.7	-1.00	Moderate	1980	297.1	-1.39	Moderate
1980	300.7	-1.86	Severe	1987	371.9	-1.00	Moderate
1984	318.7	-1.75	Severe	2006	312.4	-1.29	Moderate
2000	287.1	-1.93	Severe	1991	214.6	-1.93	Severe
				1984	188.5	-2.10	Extreme
				1996	184.2	-2.13	Extreme
				2000	187	-2.11	Extreme

Source: Field data (2009).

Table 3. Prolonged drought events in the study area.

Central division			Mukogodo division		
Drought period	Severity index	Drought category	Drought period	Severity index	Drought category
1987-1988	-1.45	Moderate	1982-1985	-2.97	Extreme
1982-1985	-3.18	Extreme	1991-1996	-6.49	Extreme
1991-1994	-2.08	Extreme	1999-2000	-2.54	Extreme
1999-2000	-2.93	Extreme	2005-2006	-2.07	Extreme

Source: Field data (2008).

in runs (that is, as prolonged droughts) were the major threats to livelihoods in the study area since they destroyed farmers' drought coping strategies hence disrupting their day to day socio-economic activities. Jackson (1989) states that one exceptionally dry year causing drought can be survived but when such conditions recur over a series of years, subsistence farmers are hard hit. Summation of severity index indicated that about 67 and 100% of all prolonged droughts (Table 3) in Central and Mukogodo divisions respectively were extremely severe.

Prolonged droughts occurred in 1987 - 1988, 1982 - 1985, 1991 - 1994 and 1999 - 2000 in Central division and in 1982 - 1985, 1991 - 1996 and 1999 - 2000 in Mukogodo division. All these droughts were extreme events except the 1987 - 1988 Central division's drought which was moderate. Prolonged and extreme droughts affected areas of large spatial extent disrupting most of the rural livelihoods. The 1982 - 1985, 1987 - 1988, 1991 - 1993, 1995 - 1996 and 1999 - 2000 extreme droughts affected not only the study area but most parts of the Kenya. Downing et al. (1985) observes that droughts of such large spatial extent correlate with their severity and refers to them as national droughts. Out of the seven national climatological disasters declared in Kenya since 1990, the 1992 - 1993, 1995 - 1996 and 1999 - 2000 extreme droughts sparked famine forcing the Kenya government to declare these droughts as national disasters and thereby requesting for relief aid from international community.

Effects of drought on agriculture

The main source of livelihood in Central and Mukogodo divisions of Laikipia district is rain-fed agriculture, which employs over 80% of the inhabitants (Flury, 1982). In Central division, mixed farming was the main source of livelihood while Mukogodo division had pastoralism as the main source of livelihood. However, crop and livestock production was constrained by the recurrent droughts in these areas.

The effects of mild droughts

Mild droughts (*ramei dorop* as known by the Maasai pastoralists) occurred when drought severity index ranged between 0 and -0.99. Annual rainfall during mild droughts ranged between 359.4 and 450.4 mm with a standard error of 13.9 in Mukogodo division and between 474.5 and 601.5 mm with a standard error of 15.6 in Central division. Farmers asserted that mild droughts had lesser effect on subsistence agriculture although they caused wilting of crops, drying up of some surface water sources such as rock catchments and seasonal streams, increased grazing radius with diminishing quantity and quality pasture. However, through evolved drought coping strategies, farmers were able to survive mild droughts without major crop and livestock losses. The Maasai pastoralists asserted that during mild droughts, pasture was still available though of poor quality. Animals were taken to higher grounds within the group ranches where more nutritious and palatable pasture was still available. During wet season, the higher lands were protected from grazing until dry periods come. Dry or early planting, minimum tillage, staggered panting and planting of drought resistant crops allowed crop farmers to obtain some harvest during mild droughts.

The effects of moderate droughts

Moderate droughts (*ramei odo* as known by the Maasai pastoralists) occurred when severity index ranged between -1.00 and -1.49. During moderate droughts, rainfall in Mukogodo Division ranged from 297.1 and 371.9 mm with a standard error of 17.3 and from 425.4 - 455.7 mm with a standard error of 10.2 in Central division. Moderate droughts caused some hardships in pastoral activities disrupting the livelihood source. During the 1987 moderate drought (-1.00) in Mukogodo Division, pastures became inadequate increasing further the grazing radius, especially for the cattle. During this drought, about 7 out of 12 months had inadequate pasture. Other effects of this drought were: drying up of more water pans, low water levels in available surface water points and declined livestock body conditions. As a result, about 1800 cattle and 3000 shoats were lost (GoK, 2006). To avoid further livestock losses, pastoralists moved their animals from one group ranch to the other within the division. Long distance covered forced pastoralist to return back home after every 3 - 4 days. As a result, pastoralists increased the number of shoats which returned back home every day providing a more reliable source of food than cattle (Ruso, Mukogodo Pastoralist, personal communication) . In Central Division, the 1993 moderate drought (-1.15) caused a 46.8 and 44.4 percent below average maize and bean yields while the 1999 moderate drought (- 1.04) caused a 41.5 and 38.9% below average maize and bean yields respectively (Table 4). Moderate droughts were associated with poor germination of seed, stunted growth (Plate 1), irregular farming calendar and reduction in area under crops, with all negative effects on the final yields (DAO, personal communication).

The effects of severe and extreme droughts

Severe and extreme droughts (ramei reai as known by the Maasai pastoralists) disrupted rural livelihoods through high livestock mortality and crop failures forcing farmers to rely on relief aid from the Kenya government. Severe and extreme droughts occurred when severity index were less than -1.5 and annual rainfall totals were less than 185 mm in Mukogodo division and less than 369 mm in Central division. In Mukogodo division, rainfall ranged from 184.2 - 214.6 mm with a standard error of 7.1 while in Central division rainfall ranged between 287. 1 and 300.7 mm with a standard error of 6.8. Severe and extreme droughts had the following effects on rural livelihoods.

Large-scale livestock losses and crop failure

The number of livestock lost depended on drought severity and duration dependent. The longer the duration and the greater the severity of the drought the higher the number of livestock lost. The extreme drought of 1991 - 1996 caused a loss of approximately 8800 cattle, 9300 sheep and 8400 goats in Mukogodo division. The 1983 - 1985 extreme drought caused a loss of about 5738 cattle, 8667 sheep and 7262 goats while the 1999 - 2000 extreme droughts caused a loss of about 5300 cattle, 6460 sheep and 6970 goats (Table 5). To cope with the effects of these severe droughts, pastoralists moved together with animals to as far as the slopes of Mount Kenya and Aberdare Ranges, a distance of up to 70 km in search of pasture and water (Ruso and Kaparo, personal communication, 2008).

In crop production areas, severe and extreme droughts caused crop failures or very low crop yields. In Central division, the 2000 extreme drought led to about 84.1 and 72.2% reduction in maize and bean production respectively. Some parts of Central division such as Kalalu area of Daiga location experienced total crop failure (CETRAD, 2004). Severe and extreme droughts caused reductions in cropped land by between 30 and 60% due

Table 4. Percentage below/ above average crop yields in Central division (1990 - 2005).

Year	Drought severity index	Drought category	Maize yields (Bags/Ha)	Percentage below/ above average (Maize)	Beans yields (Bags/Ha)	Percentage below/ above average (Beans)
1990	0.15	No drought	25	33.0	5.5	52.8
1991	-0.62	Mild	17	-9.6	3.2	-11.1
1992	-0.16	Mild	16	-14.9	3.1	-13.9
1993	-1.15	Moderate	10	-46.8	2	-44.4
1994	-0.15	Mild	8	-57.4	1.7	-52.8
1995	0.28	No drought	20	6.4	3.7	2.8
1996	-0.37	Mild	17	-9.6	3.3	-8.3
1997	1.92	No drought	28	48.9	6	66.7
1998	1.68	No drought	28	48.9	6	66.7
1999	-1.04	Moderate	11	-41.5	2.2	-38.9
2000	-1.93	Severe	3	-84.0	1	-72.2
2001	0.70	No drought	15	-20.2	2	-44.4
2002	0.05	No drought	20	6.4	3.7	2.8
2003	1.12	No drought	22	17.0	5	38.9
2004	0.45	No drought	25	33.0	4.1	13.9
2005	0.06	No drought	35	86.2	5.1	41.7
Mean yields			18.7		3.6	

Source: DAO office (2008).

Plate 1. Stunted maize crop: maize crop tussling at knee high as a result of moderate drought (Source: Field data, 2008).

Table 5. Estimated number of livestock lost during prolonged extreme droughts in Mukogodo division

Drought event	Drought severity index	Number of livestock lost		
		Cattle	Sheep	Goats
1983 - 1985	-2.76	5738	6667	7262
1991 - 1996	-6.49	8800	9300	8400
1999 - 2000	-2.54	5300	6460	6970

Source: Field data (2008).

to lack of farm inputs resulting in an unstable source of livelihood in the division. Both pastoralists and crop farmers largely depended on relief food from the Kenya government during severe and extreme droughts.

Diminished pasture quantity and quality

Livestock losses in Mukogodo Division were caused by starvation. High temperature and water stress caused by frequent severe and extreme droughts had led to encroachment and dominance of some non-palatable vegetation reducing the primary biomass production in some sections of the division (GoK, 2002). The non-palatable plant species that covered some areas of the Mukogodo rangelands were: Oldupai (*Sansavellia* sp) and prickly pear (*Opuntia megacantha*). These plant species did not coexist with grass creating bare land devoid of pasture beneath them (Plate 2).

High prevalence of drought related diseases

The prevalence of tick borne and Contagious Caprine Pleuropneumonia (CCPP) increased as drought severity heightened. According to GoK (2000) tick borne diseases, which affected cattle, was the most serious livestock health challenge during the 1999 - 2000 extreme droughts in the study area. This was attributed to the increase and spread of tick from one place to another due massive movement of livestock while searching pasture and water as tick were not controlled in anyway. CCPP disease which affected goats was quickly spread by strong winds that blew during severe and extreme droughts.

Increased desertification

Loss of agricultural rural livelihoods to drought in Kenya, the study area included, has forced some farmers to seek alternative sources of livelihoods such as selling fuel wood, charcoal burning, illegal logging and sand harvesting. USAID et al. (2009) notes that expanded practice of charcoal burning is one of the drought coping strategies employed by most households in the marginal agricultural zone. In Kwale District, for example, 3.5 million bags of charcoal were produced during the 2008 short-rains season, compared to 2.9 million in 2007 and to a 2003 - 2006 average of 2.2 million bags. This heightened production of charcoal and logging underlines the extent to which the environment is being degraded, a prerequisite for desertification, as options for coping with increased loss of livelihoods. According to Williams (2001) desertification is now a direct threat to over 250 million people around the world, and an indirect threat to a further 750 million people. Today, about 70% of all agriculturally used dry lands world over are to some degree degraded, especially in terms of their soils and plant cover. The consequences have been continued loss of livelihoods.

DISCUSSION

Central and Mukogodo divisions of Laikipia district were characterized by frequent droughts that hindered sustainable rain-fed agriculture, which was the main source of livelihood. The droughts ranged in severity from mild to extreme. Farmers' resilience to droughts reduced with increase in drought severity. Calculation of Pearson's Product Moment Correlation Coefficient (*r*) showed strong positive relationships between drought severity and number of livestock losses. At 95 percent confidence interval, the relationships were r = +0.987 for cattle and +0.947 for shoats. Therefore, as drought increased in severity, the number of livestock lost also increased. About 97.4 and 89.7% of cattle and shoats lost was directly attributed to increase in drought severity. Negative relationships between drought severity and crop yields were established. The relationships were -0.698 and -0.685 for maize and beans respectively. As drought increased in severity, crop yields decreased. About 48.7 and 46.9 percent of maize and bean reduction in Central Division was therefore, attributed to increase in drought severity.

During mild severity droughts subsistence farmers easily survived by applying various droughts coping strategies. As droughts advance in severity from moderate to extreme, the livelihood sources got disrupted triggering massive human and livestock movements and total dependency on relief aid from the Kenya government. As an alternative measure to cope with increasing drought severity, some subsistence farmers turned to non-

Plate 2. Sections of rangeland encroached by non-palatable Oldupai (*Sansavellia* sp) and prickly pear (*Opuntia megacantha*) plants (Source: Field data, 2008).

agricultural activities such as charcoal burning and sand harvesting that degraded their immediate environment. The end result has been a vicious cycle of food insecurity, inter-tribal conflicts, cattle rustling, environmental degradation and dependency on relief food.

Conclusion

Rural livelihoods in the study area were vulnerable tovagaries of extreme climate. Droughts were the major threats to farming activities disrupting the inhabitants' livelihood sources. The alternative sources of livelihood sought by the farmers exacerbated drought severity due to environmental degradation they caused leading to a vicious cycle of endless poverty and food insecurity in the study area.

ACKNOWLEDGEMENTS

This paper is drawn from my PhD thesis that focused oneffects of drought severity on subsistence agriculture in the semi arid areas of Lakipia District. I therefore, feel indebted to my supervisors Professor Josephine K. W. Ngaira and Dr. Harun O. Ogindo for their guidance in

research work and in writing this paper. I am also grateful to all respondents, particularly Lucas Moyare, a Maasai pastoralist who interpreted questionnaires to the local Maasai language. Finally I wish to thank all of my research assistants who helped me collect data in the vast Central and Mukogodo Divisions of Laikipia District.

REFERENCES

Abawi Y, Dutta S, Ritchie J (2003). Potential use of climate forecasts in water resources management. In Stone R and Patridge I (eds) Science for drought: Proceedings of the National Drought Forum at Brisbane, Australia. Department Primary Industries, Queensland, pp. 78-81.

Akhatari R, Bandarabadi SR, Saghafian B (2008). Spatio-temporal pattern of drought in northeastern Iran. Option Mediterraneennes, Series A 80: 71–77.

Awuor VO (1997). Climate change: Drought and Desertification in Kenya. In Ogola JS, Abira MA and Awuor VO (eds) Potential impacts of climate change in Kenya. Climate Network Africa, Nairobi, pp. 119-133.

Centre for Governance and Development (2005). Crisis in the Maize Production (http://www.cgd.or.ke/documents/TheMaizeProblem.pdf).

CETRAD (2004). Maize and Bean crop yield in Kalalu area of Central Division. Unpublished.

Downing TE, Mungai DN, Muturi HR (1985). Drought Climatology of Central and Eastern Kenya. In Climate Variability and Agricultural Production in Central and Eastern Kenya (no editors). MENR, Nairobi. pp. 23-60.

Giddings L, Soto M, Rutherford BM, Maarouf A (2005) Standardized precipitation index for Mexico. Atmosfera, pp. 33-56.

GoK (2000). Laikipia District agricultural annual reports. Mining Agricultural Livestock Development. Unpublished.

GoK (2002). National development plan 2002-2008. Government Printers, Nairobi, pp. 2-4.

GoK (2006). Mukogodo Division annual livestock extension reports. Mining Livestock Developmet Unpublished.

JesuitHakimani (2009). Threat to Food Security. Brief no 1/ February 2009.

Kairu E (2002). Poverty, Target Groups and Governance Environment in Laikipia District. A report for SARDEP, pp. 34-60.

Mose LO (1999). Factors affecting the distribution and use of fertilizer in Kenya: Preliminary assessment. http://www.aec.msu.edu/fs2/kenya/Dist_use_fert.pdf.

Muthui M (2007). The impact of climate change on agriculture, fisheries and pastoralist In Africa. Kenya Fed. Agric. Producers (KENFAP) (www.moreandbetter.org).

Ngaira JK (2004). Basic facts in contemporary climatology. Lake publishers and enterprises, Kisumu.

Ongwae J, Karanja F (2005). Coping With Drought and Climate Change in Kenya. Presented at the Coping with Drought and Climate Change, Nairobi, on 29 – 30 august.

Oxfam (2006). Kenya Crisis 2006 – background. (http://www.oxfamamerica.org/Resources/files/2006_Oxfam_Kenya_Background_Report.pdf)

Sharma A, Dadhwal VK, Jeganathan C, Tolpekin V (2009). Drought monitoring using standardized precipitation index: a case study for the state of Karnataka, India (http://www.gisdevelopment.net/application/natural_hazards/drought/drought_aditi.htm).

USAID, FEWSNET, GoK, WFP (2009). Kenya food security update. Nairobi, March 2009 (http://www.kenyafoodsecurity.org/monthly_bulletins/2009/march.pdf), pp. 2-3.

Williams MAJ (2001). Interactions of desertification and climate: Present understanding and future research imperatives. In Linkage between climate change and desertification. In Arid Land Newsletter No 49 May/June 2001 (http://ag.arizona.edu/OALS/ALN/aln49/williams.html).