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THE OPPORTUNITIES AND CHALLENGES FOR MITIGATING CLIMATE CHANGE THROUGH DROUGHT ADAPTIVE STRATEGIES: THE CASE OF LAIKIPIA COUNTY, KENYA

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ABSTRACT

The economy of Kenya is based on agriculture which in turn depends on rainfall performance. Over 80 percent of the Kenyan population relies on rain-fed agriculture as a livelihood source. Unfortunately, changes in its amount, timing and distribution in the last two decades have influenced the reliability of rainfall for agricultural purposes. The consequence has been recurrent food insecurity in most parts of the country and chronic in the arid and semi arid areas due to frequent droughts. To survive the harsh climatic conditions, the affected communities employ various adaptive strategies. The current study examined the drought adaptive strategies employed by subsistence farmers in the semi arid areas of Kenya in relation to mitigating climate change. Data was obtained from Mukogodo and Central Divisions of Laikipia County, Kenya. Time series was used to analyze rainfall trends. Data on effects of droughts and adaptive strategies was obtained through in-depth interviews. The inhabitants were aware of climate change with 90% and 10% of the respondents attributing the changes to human activities and divine forces, respectively. Rainfall showed a declining trend in Mukogodo Division but an increasing trend in Central Division. Nevertheless, the timing of the "long rains" and the length of the growing season in Central Division showed considerable changes. The consequences were food insecurity and livelihood destruction in the area. The adaptive strategies employed aimed at cushioning farmers against immediate problems but with minimal consideration of climate change mitigation. This paper highlights on the opportunities and challenges of mitigating climate change that farmers had through their day-to-day adaptive strategies.

Keywords: Climate Change; Droughts; Adaptive Strategies; Food insecurity

INTRODUCTION

Agriculture is the mainstay of Africa's economy employing approximately 65 percent of Africa's labor force. It accounts for about 60 percent of Africa's total export earnings and up to 40 percent of the total gross domestic product (GDP). In the least developed sub-Saharan Africa (SSA), where agriculture is largely rain-fed, agriculture employs about 70 percent and accounts for 30 percent of the GDP (International Food Policy Research Institute (IFPRI), 2009). Unfortunately, agriculture faces a myriad of challenges key among them being unreliable rainfall. For instance, droughts in Africa affect about 220 million people every year. It is projected that by 2020, yields from rain-fed crops could fall by 50 percent in some countries; while net revenues loss from crops could fall by 90 percent (UNFCCC, 2007). Between 75 and 220 million people will be facing severe water shortage. Like in other parts of SSA, agriculture contributes to 26 percent of the Kenya's GDP, 60 percent of the export and provides livelihood to over 80 percent of the population (Gitau, et al., 2009). However, over three quarters (88%) of the Kenya landmass fall in the fragile ecosystem of arid and semi arid climates where agriculture is marginal (Figure 1).

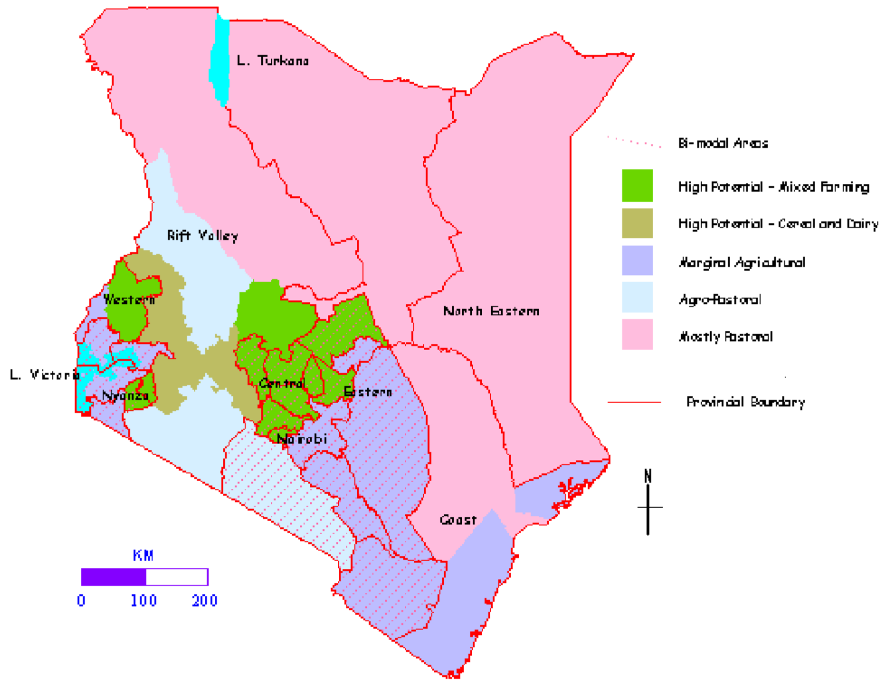

Figure 1. Production Systems in Kenya (Source: USDA, 2004)

Frequent droughts and occasional flash floods are the main challenges facing the agricultural sector in Kenya. In the last two decades, the reliability of rainfall, particularly in the arid and semi arid lands (ASALs), has declined. There have been observable changes in rainfall amounts, timing and distribution. For instance, a general decline of rainfall during the main growing season i.e. March April and May has been observed. In Kenya drought has now become a perennial problem with chronic vulnerability being concentrated in ASALs. With decreasing rainfall reliability, famine cycles have reduced from 20 years (1964-1984) to 12 years (1984-1996), to two years (2004-2006) and to yearly (2007/2008/2009/2010/ 2011 (GoK, 2010). Food insecurity is now a norm rather than an exception in most parts of the country and chronic in the ASALs.

To eke a living in these harsh climates, the inhabitants have evolved various adaptation and mitigation strategies. For most of the farmers, droughts poses the main threat to livelihood sources and therefore more emphasis has been put on drought adaptation and mitigation strategies. Food and agricultural organization (FAO), 2008) notes that adaptation is critical in protecting livelihoods and food security in many developing countries. It involves all actions aimed at coping with climatic changes that cannot be avoided and at reducing their negative impacts and also that enhance the capability to capture any benefits of climate change. Mitigation measures involve all actions aiming at reducing the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks (UNFCCC, 2009). These are long-term efforts that seek to prevent or slow down the negative impact of climate change. Though different, adaptation to and mitigation against climate change are very much intertwined in that an action in one may have important implications to the other. That is, the adaptation strategies undertaken by a community may have important implications on mitigation strategies and vice-versa. For instance, poor agricultural practices can be directly responsible for 14 percent of total greenhouse gas emissions. Deforestation currently accounts for an additional 18 percent of emissions (World future council, 2012). Greenhouse gas emission leads to warming of the surface temperature which in turns affects the climate.

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This paper highlights on the drought adaptive strategies adopted in the semi arid Laikipia County, Kenya and the opportunities and challenges that these strategies provide in mitigation climate change.

OBJECTIVES OF THE STUDY

The study sought to establish the role of drought adaptive strategies in mitigating climate change in Laikipia County, Kenya. Specific objectives were to:

1. Establish rainfall trends and drought occurrences in the county
2. Identify the drought adaptive strategies adopted in the county
3. Establish the opportunities and challenges for climate change mitigation provided by the adaptive strategies

Study Area

Data for the study was obtained from the semi arid Central and Mukogodo divisions of Laikipia County, Kenya. The divisions lie in the eastern side of Laikipia County between longitudes 36^0 34" and 37^0 24" East and between latitudes 0^0 02" South and 0^0 33" North covering an area of approximately 3,353.8 square kilometers (Figure 1). Rain-fed agriculture is the main source of livelihood for the 142,000 inhabitants of the divisions. Mixed farming (crop and livestock) dominated agricultural activities in Central division while pastoralism was the main activity in Mukogodo division. Unfortunately droughts, which are inherent in the study area, affect rain-fed subsistence agriculture.

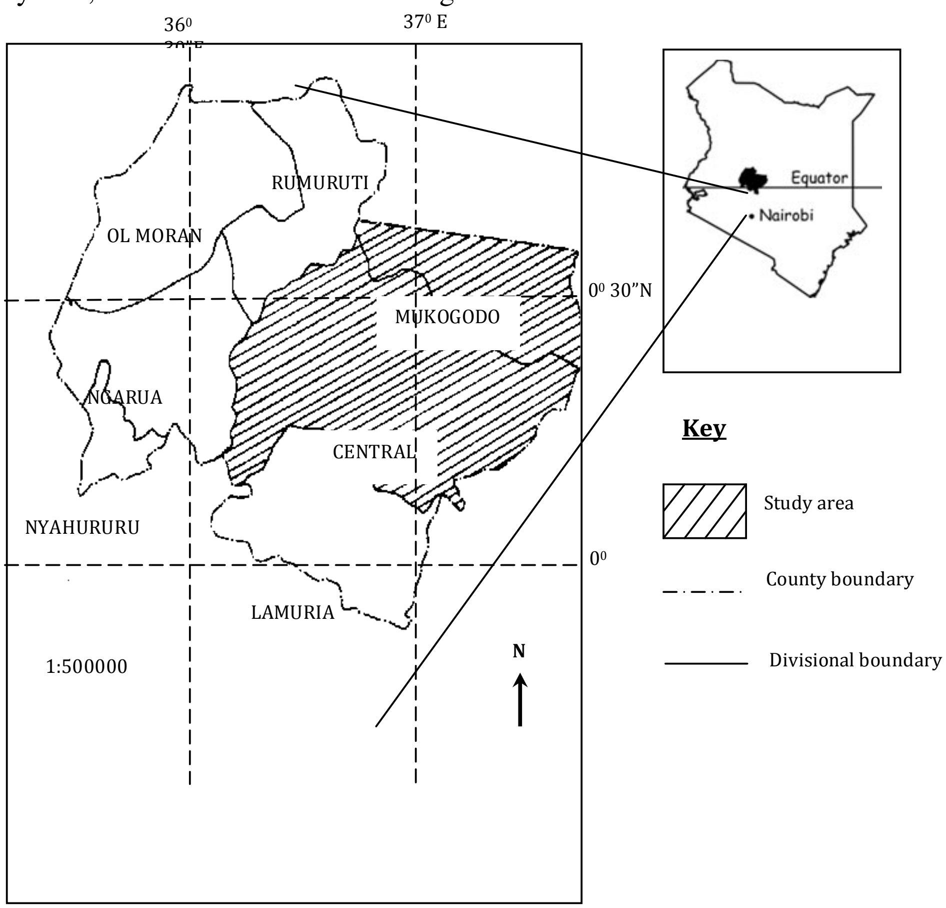

Figure 2. Location and size of Laikipia County

METHODOLOGY

The main instrument for collecting data on drought adaptive strategies was in-depth interviews. A total of 384 households practicing rain-fed subsistence agriculture were interviewed. Rainfall was used to delineate droughts since it is the single most climatic parameter that affects agriculture in the study area. Annual rainfall totals for a period of 31 years from 1975-2005 were obtained from for Laikipia Airbase meteorological station and Mpala Ranch station for Central and Mukogodo divisions respectively. The mean annual rainfall for Central division was 636.6 mm and 507.8 mm for Mukogodo division. The study considered that drought occurred when annual rainfall was below the mean. The length of the drought was obtained by summing up the number of drought years. Coefficient of variations was used to establish year-to-year variation in annual rainfall in the study area while drought intensity was calculated by subtracting the annual rainfall total for a given year from the mean annual rainfall.

RESULTS

Trends in Annual and Seasonal Rainfall

Rainfall in Central and Mukogodo divisions is highly variable, typical of the arid and semi arid climates. Annual rainfall variations between 1975 and 2005 were 28 and 43% for Central and Mukogodo divisions respectively. In Central division, annual rainfall showed a very slight increasing trend (Figure 3). The seasonal rains varied from month to month some months recording slight increase and others decrease. During the main growing season, i.e. March April and May (MAM), for instance, rainfall showed varying trends. In the month of March (beginning of growing season), rainfall showed a declining trend while the months of April and May showed increasing trends (Figure 4). Mukogodo division, which is drier than Central division, with a mean annual rainfall of 507.8 mm, showed a declining annual rainfall trend (Figure 5).

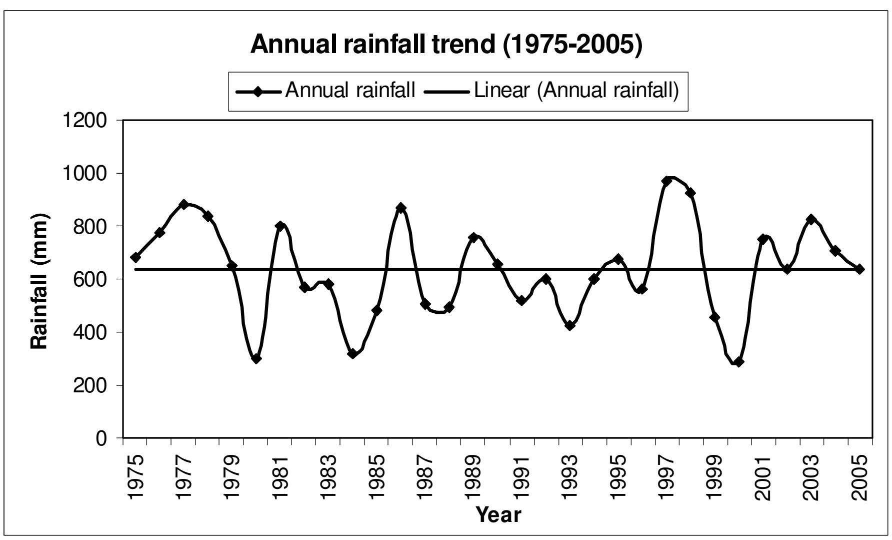

Figure 3. Annual rainfall trend for Central division

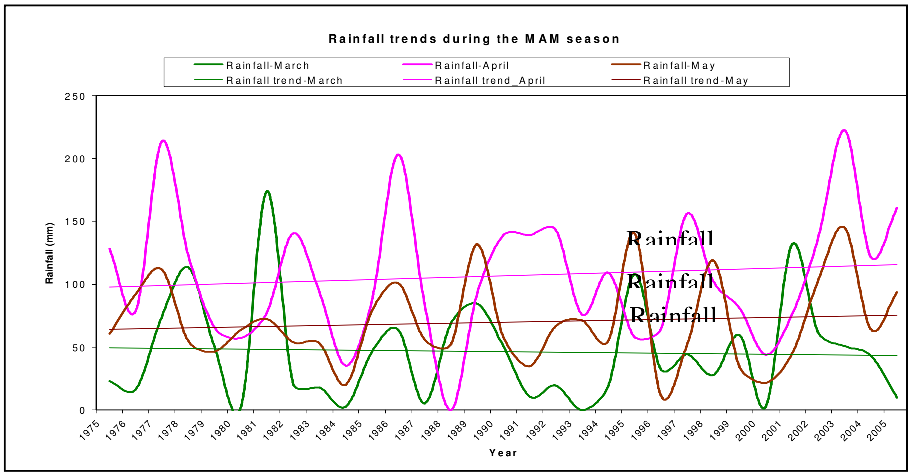

Figure 4. Rainfall trends during the MAM season for Central division

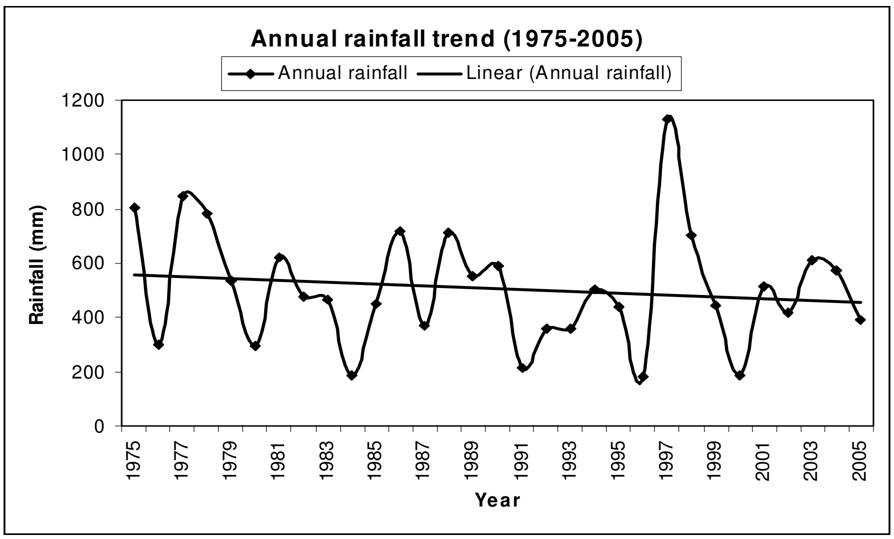

Figure 5. Annual rainfall trend for Mukogodo division

Drought Occurrences

Like in other ASALs of the world, Laikipia County is prone to frequent droughts. Statistic from rainfall data for the 31 years under study, 1975-2005, revealed that 45.2 percent (14/31) and 54.8 percent (17/31) were drought years in Central and Mukogodo divisions respectively. Droughts occurred in 1980, 1982, 1983, 1984, 1985, 1987, 1988, 1991, 1992, 1993, 1994, 1996, 1999 and 2000 in Central division. In Mukogodo division, droughts occurred in 1976, 1980, 1982, 1983, 1984, 1985, 1987, 1991, 1992, 1993, 1994, 1995, 1996, 1999, 2000, 2002 and 2005. These droughts differed in their characteristics spatially from year to year. The intensity of the drought in Central division ranged from 5.5 to 54.9 percent below the division's mean annual rainfall during the 1994 and 2000 droughts respectively. Mukogodo division had drought intensities that ranged from 1.0 to 63.7 percent below the division's mean annual rainfall during the 1994 and 1996 droughts respectively. The duration of droughts ranged from 1-6 years. Mostly droughts occurred in runs of 2-6 years. In Central division, 85.7 percent of the droughts occurred in runs of 2-4 years while 70.6% of the droughts in Mukogodo division occurred in runs of 2-6 years. The longest drought duration, which lasted for 6 years, occurred in 1991-1996 in Mukogodo division (Table 1).

Respondents (90%) linked the frequent occurrence of droughts to climate change caused by human activities. Changes in rainfall patterns were evident through the late onset of rains and shortened growing periods. The main trigger for the changes in rainfall patterns was destruction of vegetation cover, particularly deforestation. However, about 10 percent of the respondents argued that droughts were divine in nature. Unfortunately, the understanding of the science behind climate change was very low among the farmers with very few respondents being able to link greenhouse gases and climate change.

Table 1. Drought durations in Central and Mukogodo divisions (1975-2005)

Central Division			*Mukogodo Division*		
Drought Year	*Total Annual Rainfall (Mm)*	*Drought Duration*	*Drought Year*	*Total Annual Rainfall (Mm)*	*Drought Duration*
1980	300.7	1-year drought period	1976	302.3	1-year drought period
1982	571.8		1980	297.2	1-year drought period
1983	579.8		1982	476.6	
1984	318.7	4-year drought period	1983	466.8	
1985	481		1984	188.5	4-year drought period
1987	505.9		1985	448.1	
1988	495.6	2-year drought period	1987	371.9	1-year drought period
1991	519.2		1991	214.6	
1992	600.5		1992	360.7	
1993	425.4	4-year drought period	1993	359.4	
1994	601.5		1994	502.9	6-year drought period
1996	562.2	1-year drought period	1995	439.4	
1999	453.8	2-year drought period	1996	184.2	
2000	287.1		1999	443	2-year drought period
			2000	186.9	
			2002	420.2	1-year drought period
			2005	389.3	1-year drought period
Mean annual rainfall		636.6 mm	Mean annual rainfall		507.8 mm

Source: Field data, 2008

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Drought Adaptive Strategies

In the effort to cushion against food insecurity and rural vulnerability, farmers in Central and Mukogodo divisions had evolved a number of drought adaptive strategies. The section that follows examines the adopted strategies.

Minimum and zero tillage methods

Minimum and zero tillage methods were practiced by 72.3 percent of the farmers in Central division as a water conservation strategy. It involved making shallow holes for planting using machetes (*pangas*). During weeding, farmers slashed weeds in between the crop rows instead of tilling the land. As an adaptive strategy, Mati (2005) observes that the practice has been successfully used by subsistence farmers in Laikipia, Machakos and Nyando Counties of Kenya.

Agro forestry and rangeland management

Agro forestry involves the integration of trees and shrubs with crops. Farmers in Central division intercropped agricultural crops with *Grevillea robusta* (locally known as mukima) and fodder trees (alley cropping) and also planted trees along the boundaries. About 80 percent of the respondent stated that the primary reason for the planting trees was to provide fuel wood. Other reasons stated included: providing shade for the crops and maintaining soil fertility (50%), providing timber (30%) and supplementary feed for livestock (20%). Fodder trees were specifically planted as supplement feed for livestock. They stated that feed from fodder trees increases milk production. Though planted in small numbers, about 70% of the farmers had fodder trees in their farms. The most common fodder trees were *Calliandra* and *Sesbania sesban*. According to World Agroforestry Centre and UKAID (2010), the number of farmers growing fodder trees increased from 6,000 in 1995 to over 200,000 in 2005 in East Africa. Fodder tree can be fed to livestock for up to 20 years since they can withstand repeated pruning. Farmers largely depend on fodder trees as the most reliable source of livestock feed during drought years. In Musul Ranch in Mukogodo division, the Maasai pastoralists engaged in bee keeping activity through the Mukogodo Beekeepers and Environmental Conservation Group (MBEKEC). The group had set aside 810 Ha of land as a conservation area with no livestock grazing in order to improve the natural environment for bee keeping.

Extensive agriculture

To increase the harvest, 50 percent of the subsistence farmers increased the cultivated area by between 30 and 60 percent following a dry year. With fewer farm inputs, farmers sought to increase crop yields through extensive farming. Additional farming area was obtained through clearing of natural vegetation near wetlands (referred in Kikuyu as "wit mere" – get yourself a share) and in the nearby forested area such as Mount Kenya and Timau areas.

Establishment of feed reserves

Pastoralists in Mukogodo division preserved the raised grounds or the hilly areas and the forested areas as dry season grazing areas. This allowed natural regeneration of pasture during wet years and during mild droughts. The feed reserves in included: Kopiyo, Siol, Sieku, Ngare ndare, Norpanga, Kipsing, Mt. Oldonyo Ng'iro, Naserian, Tambarua and the Mukogodo forest reserve. Pastoralists were forbidden from grazing in these areas for a period of time. This is a common strategy among pastoralists in other parts of Kenya and world in general such as the Sukuma of Tanzania, the Tuareg of Ahaggar in Algeria, the Il Chamus, Turkana and Rendile of northern Kenya, the Tilemsi of Mali and the Berbers of Morocco

(Niamir, 1990). For example, the Turkana pastoralists preserved the Loima Hills (Barrow, et al. 2002).

Small-scale irrigation

Small-scale irrigation was carried out in Central division and was practiced by 20 percent of the farmers. About two percent carried out farming activities in irrigation schemes which included Gitero irrigation scheme (600 Ha), Mia Moja irrigation scheme (140 Ha), Mukima irrigation scheme (200 Ha) and Nguataniro irrigation scheme (360 Ha) (Kairu, 2002). About 18 percent practiced small-scale irrigation at household levels. Other major small-scale irrigation schemes in the Kenya arid lands include: the Elgeyo-Marakwet system in Keiyo and Marakwet Counties, the Pokot irrigation system in West Pokot County, the Mwatate irrigation system in Taita-Taveta County and the North Iveti Hills irrigation system in Machakos County (Akong'a and Kareithi, 1998).

Increasing the number of livestock during the inter-drought period

Increasing the number of livestock during inter-drought periods through restricted commercial sales or slaughtering is a common practice among the pastoralists (McCabe, 1990; Ngaira, 1999). In addition, pastoralists in Mukogodo division increased their herd sizes through purchasing (40%) and natural increase (60%). The aim was to recover the lost herd during drought periods. To pastoralists, large livestock population acted as insurance against loss of the entire herd to droughts.

Increasing the number of sheep and goats (shoats) in the herds

The number shoat has been increasing at a higher rate than cattle in Laikipia County in general. Between 1999 and 2001 for instance, UNEP and GoK (2006) observe that the overall rise in livestock numbers by 4.1 percent in the county was caused by increased number of shoats since cattle population declined by 26.9 percent. The Maasai pastoralists in Mukogodo division were deliberately replacing the traditional cattle-dominated with shoat-dominated herds. This was for three main reasons: First, shoats were more resilient to droughts; second, they have a higher reproduction rate (average gestation period for shoats is 150 days) than that of cattle (average gestation period for cattle is 280 days). Thus, shoats replaced the lost herds during severe and extreme droughts quicker than cattle; and third, shoats were easily sold during drought events providing pastoralists with the necessary cash to buy grains from crop farmers. In 95 percent of the Maasai pastoralists' herd, 75-80 percent was shoats while 5 percent of the Maasai pastoralists kept shoats only. Similar trend has been observed among the pastoralists in Sub-Saharan Africa (Toutain, et al. 2010). For instance, the Borana pastoralists in Ethiopia have reduced the number of cattle while at the same time increasing the shoat population in their herds (Akillu and Catley, 2010). While increase in livestock numbers causes overgrazing, the feeding behaviour of shoats accelerates the loss of vegetation cover. The ecological impact of the overgrazing is loss of biodiversity.

Feeding livestock with tree twigs and leaves

During drought periods, livestock were fed with twigs and leaves from selected tree species. In Mukogodo division, twigs and leaves from *Euclea divinorum* (Olkingei as known by the Maasai pastoralists), *Acacia lahai* (Oltepesi), *Olea africana* (Lorien) (Plate 1) and Olkerosha trees were fed to livestock. Cutting was done in a careful and selective manner. However, as drought shocks increased beyond pastoralists' adaptive mechanisms, the cutting of the twigs and leaves had become increasingly non-selective inhibiting proper tree growth and sometimes drying up of some trees. The patchy distribution of trees in the county especially

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near the homesteads in Mukogodo division was attributed by 68% of the Maasai pastoralists to this practice.

Plate 1. Destroyed trees through non-selective cutting

Charcoal burning

Farming activities, particularly crop growing, were less promising and most farmers (80%) produced barely enough food from their farms. To meet the deficits, some farmers (28%) in Central division engaged in non-farm activities which included small-scale businesses (groceries, shops, hotels and hawking) and selling of firewood and charcoal burning. About six percent of these farmers engaged in the later (Plate 2). Firewood collection and charcoal burning was largely practiced by the families living near Mukogodo forest. In addition to pastoralism, about half of the 30 percent who engaged in other economic activities in Mukogodo division practiced selling of firewood and charcoal burning. This practice led to destruction of forests and vegetation cover.

Plate 2. Charcoal burning in Central division

Burning grazing fields for regeneration of pasture

The Maasai pastoralists used fire to clear unwanted trees and shrubs so as to allow the growth of an improved sward of grass. The carefully regulated fire regime altered the composition of the pasture at the same time enhancing re-growth of more nutritious and palatable grasses.

DISCUSSION

Rainfall amount was lower and more varied in Mukogodo than in Central division. This is due to the proximity of the division to the low very arid northern corridor of Kenya. As a result, the division is more prone severe droughts compared to Central division. The climate of Mukogodo division was only suitable for pastoralism. Though annual rainfall showed a very slight increasing trend, a condition suitable for crop production, in Central division the length of growing period appeared to be shrinking due to decline in the March rainfall. This phenomenon caused delayed planting which affected crop farming. Thus crop and livestock farming in the study area were largely threatened by frequent droughts.

The 1980 and 1990 decades being characterized by prolonged droughts. The drought durations were shorter for Central division spanning for up to 4 years and longer in Mukogodo Division spanning up to 6 years. Central division experienced two prolonged droughts each spanning for four years, i.e. 1982-85 and 1991-94. Similarly Mukogodo division had two prolonged droughts, one spanning for four years (1982-85) and the other spanning for six years (1991-1996). These prolonged droughts were of large spatial extent since they did not only affect the divisions concurrently but also affected most parts of the country. For example, the 1984, 1991-92, 1994 droughts were declared as national disasters by the government of Kenya. The year 2000 drought was as a result of La Niña weather event that affected the Greater Horn of Africa (GHA) in 1999-2000. Other notable droughts with high intensities occurred in 1980 and 1984. The 1996 drought in Mukogodo division had 8 months of no rain and was referred to as *ramei olakiralokidongoi* (the drought that killed everything) by the Maasai pastoralists.

In the attempt to adapt to droughts, there was little or no consideration for mitigation of climate change due to limited knowledge on mitigation measures. However, a number of opportunities and challenges for mitigating climate change through various droughts adaptive strategies emerged. According to Desjardins (2012), the dominant option for climate change mitigation in agriculture is through sequestration of carbon in soils. Carbon sequestration refers to the processes that remove carbon from the atmosphere. In Central and Mukogodo divisions various practices aimed at adapting to droughts provided opportunities for mitigating climate change through carbon dioxide sequestration. For instance, Minimum and zero tillage methods resulted in soil carbon gain. In other words, these methods minimize soil disturbances to soil carbon that can result in high levels of emissions to the atmosphere (Dahal and Bajracharya, 2010). Desjardins, (2012) and IPCC (2007) observe that soil carbon stocks are considerably depleted by farming through soil disturbance during tillage. Soils can sequester as much as 20 percent of carbon emissions annually (Cheserek, 2010) if proper agricultural practices such as minimum or zero tillage methods can be adopted. Over the next 25 to 50 years, estimates indicate that properly managed agricultural soils could be a potential sink of as high as 30 to 60 Giga tones of carbon globally (Dahal and Bajracharya, 2010).

Land management practices that increase the yield and biomass productivity increase soil organic matter content which helps in carbon sequestration. Thus, all adaptive strategies that involved conservation and/ or improvement of vegetation cover in the study area enhanced carbon sequestration. These strategies included: establishment of dry-season grazing reserves, agro forestry and rangeland management. The thick vegetation cover including trees and

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thicket in the grazing reserves and the new plant biomass in agricultural lands under agro forestry enhances carbon dioxide (CO_2) sequestration (FAO, 2008). For instance, with the assuming mean carbon content of above ground biomass of 50 percent, one hectare under agro forestry can store 9, 21, 50, and 63 giga tons of CO_2 in semiarid, sub-humid, humid, and temperate regions respectively (Rao, et al. 2007). Through small-scale irrigation, more yields were obtained from smaller areas and for less effort. In addition, it encouraged the growth of new plant biomass in otherwise bare land. Thus, smaller areas were cleared of vegetation while at the same time more crop biomass was added restoring CO_2 pools. IPCC (2007) observes that expanding agricultural production through effective irrigation enhances carbon storage in soils through increased yields and residue returns. Under mixed farming system, farmer used livestock manure during planting. Artificial fertilizers were infrequently used. The use of livestock manure enhanced the reduction of methane (CH_4) while at the same time less usage of artificial fertilizers reduced nitrous oxide (N_2O) emissions.

On the other hand, some of the adopted drought adaptive strategies posed challenges to the mitigation of climate change by increasing the amount of carbon dioxide in the atmosphere. These strategies to a large extent involved destruction of vegetation cover. Extensive agriculture, for instance, led to the conversion of vegetated and forested areas to cropland hence reducing the amount of carbon sequestered. Batjes (1996) and IPCC (2007) observes that intensive farming, which includes efficient use of fertilizers, better irrigation and use of high yielding crop strain, that increases productivity on the existing croplands, reduces carbon dioxide emission. Other strategies that enhanced reduction in CO_2 sequestration included: charcoal burning and firewood collection, burning grazing fields for regeneration of pasture, increasing the number of livestock during the inter-drought period, increasing the number of shoats in the herds and feeding livestock with tree leaves and twigs. Trees possess about 20 percent carbon by weight and biomass of forest acts as a carbon sink. This carbon is stored in the form of wood and vegetation through carbon sequestration. Decomposing plant matter acts as carbon store (Trumper, 2009). Globally, deforestation accounts for 18 percent of emissions (World future council, 2012). Strategies that induce soil erosion cause an estimated emission of carbon of about 1.1 giga tons per year (Dahal and Bajracharya, 2010).

CONCLUSION AND RECOMMENDATION

The main threat to agricultural activities in Laikipia County was drought. Rainfall in Mukogodo division had a higher year-to-year variation and showed a decreasing trend. In Central division rainfall, though varied from year to year, showed an increasing trend. However, decreasing rainfall amount during the beginning of the main growing season caused a shortened period. Thus, poor rainfall performance in the study area affected substance rain-fed agriculture. The adopted drought adaptive strategies enabled farmers to survive the harsh climate. Unfortunately, farmers had little information on climate mitigation strategies save for planting of trees and therefore put no consideration on the effects of the adopted strategies on future climate. Though the adaptation measures were important in dealing with the current and irreversible impacts of climate change, mitigation measures should be the focal point in reducing the long-term impacts.

The study recommends that an efficient mix of adaptation and mitigation strategies that limit the short and long-term impact of climate change should be encouraged. Such strategies involve prevention and removal of maladaptive strategies that enhances rural vulnerability in the long run than reducing. Strategies that involve conservation or improvement of vegetation cover, particularly agro-forestry, are most appropriate. This is because they are of economic importance to rural livelihoods and at the same time enhance carbon sequestration.

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