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Effect of Climate Change on Small Scale Agricultural Production and Food Security in Kitui District, Kenya

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ABSTRACT

Most of the world's arid and semi-arid lands (ASALs) are found in the developing countries. These ASALs face many challenges some of which are as a result of the declining availability of water resources and increasing threats from climate change. Climate change is expected to affect the availability of freshwater worldwide, the productivity and fertility of soils, and amount of food produced by farmers in the tropical countries majority of which are developing countries. While contributing the least to global warming, it is the developing countries that will suffer the most from it, having the least capacity to adapt. Kitui District is one of the semi-arid districts in Kenya where the impact of climate change has been seriously felt. This paper examines the effect of climate change on food production and security among small scale farmers in the semi-arid region of Kitui District. Various methods were employed in data collection among them structured questionnaires, oral interviews with key informants, focus group discussion and direct observation. The collected data was analyzed using both descriptive and inferential statistics. The results show that most farmers (87.5% n=350) had less than five acres of land which was not enough to grow adequate food for the household, did not have an alternative source of income (78.5%, n =314) and experienced reduced agricultural production due to reduced rainfall (97%, n =388). There was a significant difference between the size of the farm and land use (χ^2=143.492, df=1, P=0.000). The results indicate climate change has had a negative effect on food production; the temperatures are increasing, extreme climatic conditions have become more frequent while the amount and frequency of rainfall have reduced considerably. This has led to a reduction in agricultural production in the district which has consequently resulted in food shortages in the household. The results also show that very few of the farmers have adopted coping strategies against the effects of the changing climate. It recommends that small scale farmers need to be assisted financially and technically to enable them employ coping strategies that would cushion their agricultural activities against the harmful effects of climate change.

Keywords: Climate change, Agricultural production, Food security.

INTRODUCTION

Kenya has a land mass of about 582,350 km^2 of which only 25% is arable while the remaining 75% consists of arid and semi-arid (ASALs) (GOK, 2O10). Climate change is a reality and its effects are being felt everywhere. Due to climate change and some human factors that influence desertification, the extent of ASALs is increasing (GOK, 2010). The country's natural resources, particularly its rich flora and fauna, are among the most valuable but which are under threat of extinction due to climate change. Most of the ASALs depend on agriculture (both crop production and animal rearing) which depend on rainfall. The amount of rainfall in these regions has been declining due to the changing climatic conditions. The rainfall received in the ASAL's has become unpredictable with the amounts reducing annually. In some regions, the amount of rainfall received has diminished considerably making them agriculturally unproductive. The temperatures received in these regions have also been increasing due to the changing climate which has resulted in a reduction in the economic activities practiced. Globally, increasing evidence of changing climate due to rising carbon emissions (CO) and other greenhouse gases (GHG) into the atmosphere are being observed. For the poor countries in the tropics and subtropics particularly, every observation and prediction about health, food security, water shortage, natural disasters like famine, drought, floods and conflict are worsening at an alarming rate (Liverman, 2009).

In developing nations, agriculture is expected to be more vulnerable to climate change than in industrialized countries especially in the tropics where farmers have limited ability to adapt to the changing climate. The effects of climate change on world agriculture depend not only on changing climatic conditions, but also on the agricultural sector's ability to adapt through adapting to new changes in technology. It also depends on its ability to increase supply of food as the population increases and environmental conditions, such as water availability and soil quality change.

Kitui District is one of the semi-arid districts in Kenya. A large part of the district receives erratic and unreliable rainfall with most of the areas being generally hot and dry leading to high rate of evaporation (GOK, 2009a). The district has been experiencing a reduction in food production because of its vulnerability to changing and erratic rainfall pattern which has adversely affected food production. Variations in climatic conditions experienced in the district are thought to be responsible for the changes in food production. Agricultural production has been and continues to be affected by the changing climate. Farmers have experienced variations in their agricultural production, but some of whom are not aware of the variations that have taken place in the climate and how this has affected agricultural production. According to Lobell and Burke (2010), a large majority of the world's poor continue to live in rural areas and depend on agriculture for their livelihoods. Given that agriculture everywhere remains dependent on weather, they say that changes in climate have the ability to disproportionally affect these poor populations' livelihoods. The negative effects of extreme weather conditions are heavily felt on agricultural activities which are dictated by the climatic conditions of a place. The performance of agriculture in Kenya has been declining with many regions reporting reduction in yields yearly. Various factors have been cited to be the causes of poor agricultural productivity of the country. These include reduced fertilizer usage, land fragmentation and changes in the climatic conditions among others.

Kitui district, being a semi-arid region, is experiencing the effects of a changing climate especially in the agricultural sector. Existing measures aimed at climate adaptation in the district largely focus on increasing agriculture's drought resistance. The purpose of this study was to assess the impact of climate change on agricultural production among small scale farmers in the semi-arid region of Kitui. This study investigated the effects of climate change on small scale agricultural production and how it has affected food security in the district. It also determined the farmers coping strategies to the effects of climate change and

recommended additional strategies that could be put in place by the farmers so as to improve the land production amid changing climatic conditions.

Justification of The Study

The climate change being experienced globally has resulted in changes in agricultural production. Many countries worldwide are facing food crises due to manmade conflicts and natural disasters. Kenya, being an agricultural country depends almost entirely on rain fed agriculture. However, the changes taking place in the climatic conditions have led to drastic reduction in the food production in the country yet most of her population relies on agricultural production for their survival. Over reliance on rain fed agricultural subsistence production by a large percentage of her population has also contributed to food shortages in the country (Sigot*et al.*, 1998).

For Kenya to address the issue of climate change and adaption adequately, it needs a lot of information systems, advocacy, research and adaptation strategies which require a lot of finances. The limited research and subsequently lack of adequate information has been one of the major shortcomings towards adapting to the changing climate by the farmers.

Despite the fact that climate change has affected agriculture, agricultural activities contribute approximately 20 % of the annual increase in anthropogenic greenhouse emissions. These gases contribute to global warming through Carbon dioxide (CO_2), Methane (CH4) and Nitrous oxide (N_2O) gas emissions which lead to global warming (Aydinalp and Cresser, 2008).Kitui district which is located in Kitui County experiences semi-arid conditions and drought regularly. This makes most parts very unproductive due to unreliable and irregular rainfall. The district experiences regular food shortages as a result of the unreliable weather conditions.

This study was carried out in Kitui district because of its vulnerability to changing and erratic rainfall pattern which has adversely affected food production. Variations in climatic conditions experienced in the district are thought to be responsible for the changes in food production. A large part of Kitui district receives erratic and unreliable rainfall with most of the areas being generally hot and dry leading to high rate of evaporation.

Scope of the Study

This study looked at the variations that have taken place in the climate of Kitui district and how it has affected agricultural production. The main climatic variables studied were rainfall and temperature and their effect on agricultural production. It focused on the climatic conditions specifically on the temperature and rainfall regimes and analyzed their effect on small scale agricultural production and food security. The study also analyzed some of the coping strategies employed by the farmers so as to mitigate against the harmful effects of climate change. The study was undertaken in parts of Kitui district, which is one of the districts that make up Kitui County and was carried out in both high and low potential areas in the district. It looked at the changes that have taken place in rainfall and temperature and how they have affected food production and security among small scale farmers in the district.

MATERIAL AND METHODS

Study Area

Kitui District is located in Kitui County in Eastern Province, Kenya. It is located in the southern part of Kenya. It borders Machakos and Makueni districts to the west, Mwingi to the north, Tana River to the east and TaitaTaveta to the south. The district is located between longitudes 37º45´ and 39º0´ East and Latitudes 0º3.7´ and 3º0´ South (GOK, 2009b). Kitui County covers an area of approximately 20,402 km² including 6,903 km² occupied by the Tsavo National Park. The altitude of the district ranges between 400 m and 1800 m above sea level. The climate of Kitui district is semi-arid with very erratic and unreliable rainfall. It

receives about 710 mm which occurs mainly during the rainy seasons (one long around May and June, and one short, around September and October) with no rainfall received during the dry season (GOK, 2009b). The annual average rainfall ranges between 500-1050mm with 40 per cent reliability. The district experiences high temperatures throughout the year, which range from 16˚C to 34˚C. Due to limited rainfall received, surface water sources are very scarce. The major sources of surface water are seasonal rivers that form during the rainy seasons and dry up immediately after the rains (GOK, 2009b).

In Kitui District, according to GOK (2009b), the number of people employed by the agricultural sector was estimated at 140,000. The average farm size in the district is 5 hectares (GOK, 2009b) and this study mainly targeted small scale farmers with five or less acres of land.

Sampling Procedure and Sample Selection

The unit of study was small scale farmers who planted cash crops and food crops and also kept livestock. Simple random sampling was employed to select farmers that formed the study sample. Using Glenn Israel (2009) formula to arrive at the sample size, a total of 400 small scale farmers were selected to form the study population. The district land survey map which shows the land demarcation boundaries was used to randomly select the farms. The farms were given numbers, and then lottery method was employed to randomly select the farms that formed the study sample. Purposive sampling was used to handpick key informants who possessed the required characteristics (Mugenda and Mugenda, 2003; Sarantakos, 2005). More data was sourced from secondary sources of information such as journal, research reports, textbooks and government reports.

Data Collection Procedure

The data were collected using different methods which included direct observation, structured questionnaire and interviews with key informants. Structured questionnaires were used to gather information from the farmers. Questionnaire administration was conducted face to face with the help of trained research assistants. Questionnaire surveys provided data on various socio-economic issues including gender, age, education level, amount of land owned by the farmers, alternative sources of income and the variation in agricultural yields. Direct observation was used by the researcher to verify and authenticate the information gathered through questionnaires and interviews particularly on the types and amount of food crops grown and the sizes of farms owned by farmers.

It was also used to verify the coping strategies that are employed by the farmers against climate change. Agricultural extension officers were interviewed on the climatic variations and changes that were taking place in the study area and how these changes affect agricultural production. They were also interviewed on the extension services provided to farmers. Meteorological officers were interviewed on the weather variations and extremes experienced in the district. Secondary data was collected from books, journals, district development plans, the internet, project reports, Ministry of Agriculture, thesis, Meteorological department and statistical abstracts among others. These included rainfall and temperature data recorded over the many years.

Data Analysis

Data collected were analysed using SPSS where frequencies and percentages were derived. Spearman's coefficient of correlation was used to determine the correlation between agricultural production and elements of climate (rainfall and temperature) and also to determine the relationship between food production and household food security.

RESULTS

Demographic Characteristics of the Farmers

The study shows that 56.6% of the respondents were female while 43.5% were male. Out of the 400 respondents, 318 were married, 46 were single (20 male and 26 female), 25 were widowed while 11 were single parents. Regarding education, 55% of the respondents had only attained primary level of education, 33% had attained secondary level while 9.5% of the respondents had attained tertiary education. Generally, the education level in Kitui District is low. Regarding the number of people in the household, 13.5% of the respondents had less than three people in the household while 40.7% had between four to six people and 38% (n=152) had between seven to nine people. Only 7.8% respondents had more than ten people in their households.

A large percentage of the respondents (78.5%, n=314) did not have other sources of income and therefore mainly relied on their farms for subsistence. Only 21.5% (n=86) reported that they had other sources of income, some had a few rental houses, some were retirees and therefore received their pension monthly while others received a regular income from their children who were working. Other sources of income included bee keeping, basket weaving and charcoal burning

Land Ownership and Crop Production

Regarding land ownership, 27% of the farmers own less than one acre of land, 60.5% own more than one but less than five acres of land while only 12.5% of the farmers had more than five acres of land. This implies that a large portion of the farmers in the study area were small scale farmers who relied almost entirely on their farms for their livelihood. In terms of land usage, 41% used the land for crop growing, 6.25% used for livestock rearing while 52.25% practiced both crop growing and livestock rearing. A small fraction (15.2%) of the farmers had adequate land while the remaining 84.8% did not have enough land for their agricultural needs. 89% of the respondents grew food crops only, 1% grew cash crops while 10% grew both food and cash crops. Majority (72.8%) of the respondents did not grow enough food while the remaining 27.2% grew food that was adequate for their household consumption.

Respondents' Perceptions on Climate Variability and Food Production

The respondents were asked whether they had noticed any changes in the temperature experienced in the area for the last thirty years. Table 1 shows that 83.3% (333) of the respondents admitted to have noticed dry spells which led to a reduction in their production. 1.7%(7) respondents reported to have experienced dry spell but which did not have any effects on their agricultural production.

Table 1: Respondents perceptions on extreme weather conditions and agricultural production

		What extreme weather conditions have you been experiencing?			Total
		Dry spell	Floods	Strong winds	
How the changes in temperature affected agricultural production	Reduced production	333 (83.3%)	57 (14.3%)	3 (0.7%)	393 (98.3%)
	No change in the production	7 (1.7%)	0	0	7 (1.7%)

The study sought to find out if the level of education attained by the respondents influenced the type of crops grown by the respondents.

From the cross tabulation above (Table 2), 98.6% of the respondents engaged in food crop farming while only 1.4% (5) planted cash crops. 97.4% (218) of the respondents who attained

primary school education planted food crops while only 1.6% (5) planted cash crops. All the respondents (123) who attained secondary and tertiary education (38) planted food crops only.

Table 2: Cross tabulation between education level and the type of crops grown

			Education level				Total
			Primary	Secondary	Tertiary	Other	
Type of crops grown on the land	Food crops	Count	218	132	38	7	343
		% within Education level	97.4%	100.0%	100.0%	100.0%	98.6%
	Cash crops	Count	5	0	0	0	5
		% within Education level	1.6%	0	0	0	1.4%
Total		Count	223	132	38	7	400
		% within Education level	100.0%	100.0%	100.0%	100.0%	100.0%

The Chi-Square test in Table 3 shows that there is no significant difference between education level and type of crops grown ($\chi^2 = 4.122$,df =1, p= 0.249). The study findings show that education level of the respondents did not determine the type of crops grown in the area.

Table 3: Chi-Square test for education level and types of crops grown

	Value	DF	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.122[a]	3	0.249
Likelihood Ratio	6.006	3	0.111
Linear-by-Linear Association	3.311	1	0.069
N of Valid Cases	400		

The low level of education in the study area was found to be one of the factors that has made many farmers not to have the most recent up-to-date information on how to grow food efficiently and economically.

Rainfall and Temperature variability in Kitui District

The graph in Figure 1 shows that whereas some rainfall was recorded every year, dry spells were as well experienced yearly where no rainfall at all was recorded (zero).The average rainfall received in most of the years was below 250mm, except for 1995, 1998, 2000, 2002 and 2007. The year 1998 received high rainfall because of El Nino which resulted in comparatively higher rainfall amounts than the other years. This resulted in severe flood in some parts in Kenya leading to great losses of agricultural crops, livestock and other property. The rainfall trend in Figure 1 show peaks in the years 1994-1995, 1999-2000, and 2007-2008. The lowest rainfall was recorded in 1991, 1996, 2000, 2003 and 2009.

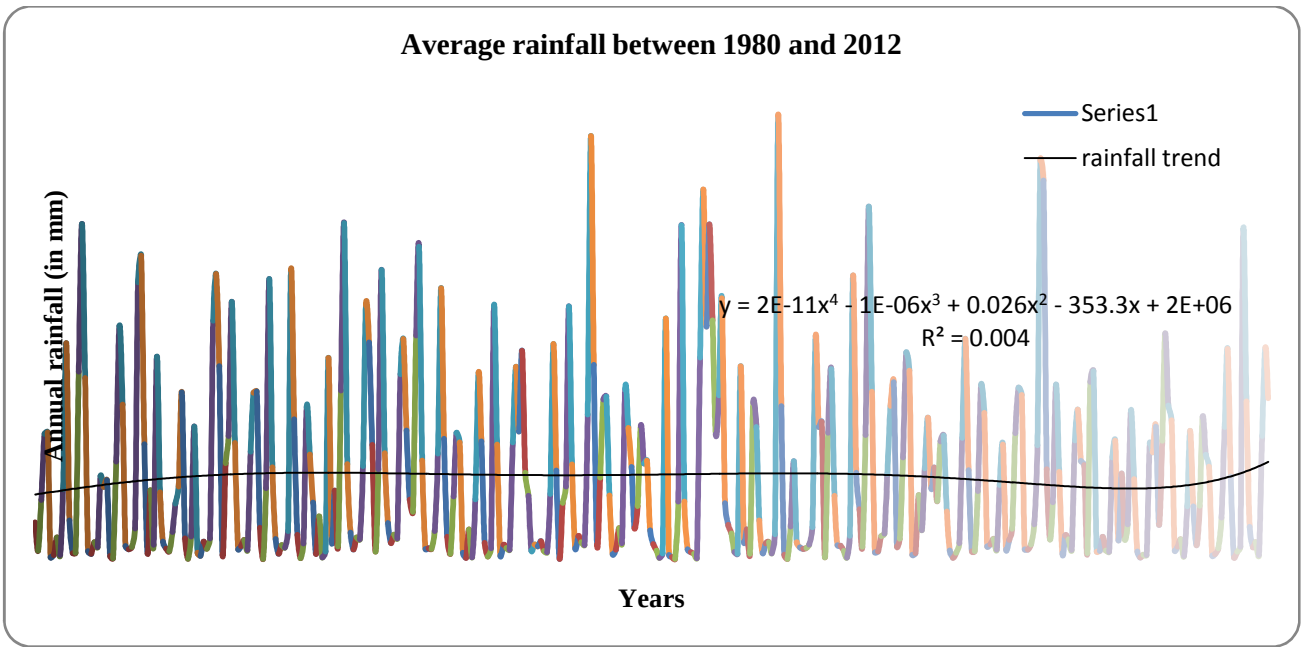

Fig 1: Average rainfall for Kitui District

Temperature variability

Just like rainfall, temperature in the study area has been fluctuating over the last 30 years. This study examined the average temperature experienced in the last 30 years to ascertain the variations that have taken place. (Figure 2).

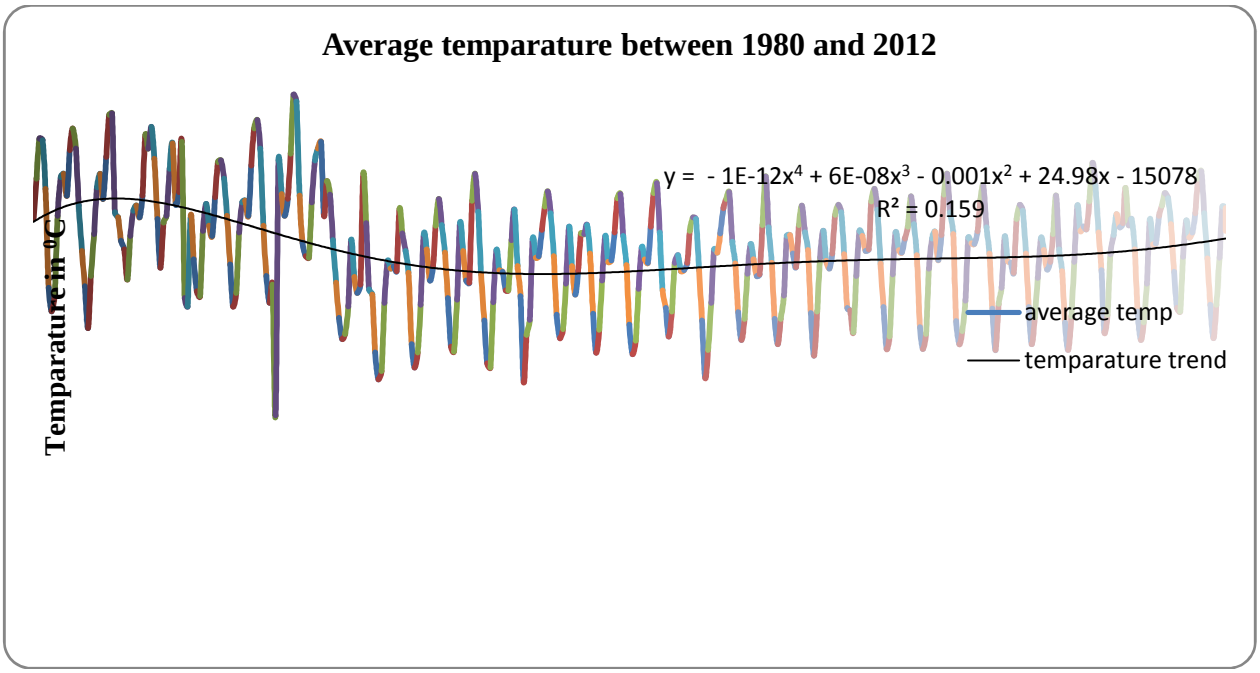

Fig 2: Average Temperature for Kitui District

DISCUSSION

Climate Change and Agricultural Production in Kitui District

The study area has been experiencing high rainfall variability. The rainfall graph (Fig 1) shows the average rainfall for three stations in Makindu, Machakos and Embu. These stations were the nearest to the study area and which had regular weather records for than 30 years. Kitui district did not have a manned weather station and therefore did not have consistent weather readings.

The study area has been experiencing high rainfall variability (Fig 1) which makes it very unpredictable and unreliable for agricultural use. The study results concur with Kurukulasuriya et al (2006) who report that Sub-Saharan Africa (SSA) is predicted to be particularly hard hit by global warming because it already experiences high temperatures and low and highly variable precipitation. They further report that it is because the economies of the Sub Saharan countries highly depend on agriculture and that adoption of modern technology is low. (Thornton *et al.,* 2006; Conway *et al.,* 2007) argue that currently it is not clear whether a relationship exists between both El Niño or La Niña events and prolonged drought or particularly wet periods over much of the Greater Horn of Africa.

The livelihood and economies of the local communities in Kitui district is linked to the climatic characteristics experienced in the district. The weather conditions will become more variable than at present, with increasing frequency and severity of extreme events globally. Rainfall received has been varying yearly and it is estimated that many of theworld's rangelands in the semi-arid areas like Kitui district will have severewater deficits so that any further decline in water resources will greatly impact on the livelihoods and land carrying capacity in these regions. As a result of the increased climate variability and droughts, agricultural production in Kitui is expected to decline drastically. This confirms Ludi (2009) that climatic fluctuations will be most pronounced in semi-arid and sub-humid regions and are likely to reduce crop yields and livestock numbers and productivity. The effects will be felt more because these areas are mostly in Sub-Saharan Africa and South Asia. These are the poorest regions with the highest levels of chronic undernourishment which will be exposed to the highest degree of instability (Ludi, 2009).

The rainfall variations experienced have affected agricultural production with most of the respondents reporting a decline in agricultural production and livestock numbers. The most severe losses occurred during the prolonged droughts which led to all the green vegetation drying up and the death of all the livestock reared. Livestock which represent a significant resource is seen as a source of food security in times of crop failure because they are sold so as to provide income for purchasing foodstuff. The main livestock kept are cattle, goats and donkeys which are not used for food, but which are sold in times of need. Over the past years, climate change in terms of long-term changes in mean temperature or precipitation normal, as well as an increased frequency of extreme climate effects has gradually been recognized as an additional factor which will have a significant weight on the form, scale, and spatial and temporal impact on agricultural productivity (Kurukulasuriya and Rosenthal, 2003). The general consensus to emerge from this study is that in the absence of adequate response strategies to long-term climate change as well as to climate variability, diverse and region-specific impacts will become more apparent. This will have an even greater effect on agricultural production and food security of many arid and semi-arid regions in Kenya. There is need for concerted effort to apply strategies that will help to cushion the farmers in these regions from the harmful effects of the changing climate.

Temperature variability

Data from 1990 to 2012 reveals that between 1980 and 1988 the temperature seemed to fluctuate at between 20° and 25° Celsius, but between 1988 and 2012 it seemed to oscillate at between 18° and 24° Celsius. It can therefore be concluded that the average temperature in the

region has been increasing over time. It is expected that climate change will lead to temperature increase in some areas and a reduction in other regions.

The temperature changes taking place in the study area are very small but its effect over a long time has led to an increase in the temperatures experienced. During the 21st century, this warming trend and changes in precipitation patterns are expected to continue. The warming will be greatest over the interior of the semi-arid margins of the Sahara and central southern Africa (Ochola, 2009). He acknowledges that these effects will be accompanied by a rise in sea level and increased frequency of extreme weather events. These climatic conditions will combine with social, economic and environmental factors to exacerbate the region's vulnerabilities including lack of water, food insecurity, diseases, conflict and degradation of natural resources.

Most of the farmers in the study area which is among the ASAL regions in Kenya,incur losses when the pastures dry up during drought and periods of over-grazing. Also, in times of water scarcity, sometimes livestock are forced to use the same water resources as humans which leads to diseases being transferred between humans and animals and vice versa. Livestock keeping also damages local vegetation cover, which has an effect on climate. Livestock keeping was also found to be beneficial to the farmers because manure from the animals was used in the farms to improve fertility. As earlier discussed, crop growing and livestock production are carried out together because livestock is seen as a source of food security in times of crop failure. However, livestock rearing is also affected by drought which leads to the death of the animals due to lack of pasture and water. The impacts of climate change on livestock are likely to be felt from an increased severity and frequency of drought (Ziervogel*et al.*, 2008).

In Kenya, approximately 60 per cent of the country's livestock is found in the ASALs, which constitute about 80 per cent of the country's land mass and which are home of 30 per cent of the country's population (GOK, 2013).GOK (2013) reports that pastoralism is the dominant form of livestock-keeping in the ASALs and given the option of mobility to manage climate variability, pastoralism is inherently adaptive. However, the increased frequencies of extreme weather events multiply the impact of factors that constrain pastoralists' livelihoods.

Other Factors That Influence Agricultural Production in Kitui District

Majority of the local community in the study area depend largely on their farms. As earlier discussed in the results, some of the respondents were below 30 years while others were above 50 years of age. Sometimes advanced age comes with fatigue and reduced productivity. However, advanced age does not always result in low production. The higher the age of the household head, the more stable the economy of the farm household, because older people have also relatively richer experiences of the social and physical environments as well as greater experience of farming activities (Hofferth, 2003) .

The amount of income in a household in Kitui District was one of the factors that influenced agricultural production. In a situation where farmers did not have an alternative source of income, agricultural production was found to be relatively low especially among the small scale farmers. Majority of the respondents did not have other sources of income other than their farms. Due to the smallness of the farms, the farmers did not get enough income from their farms to meet all their household income requirements. This may not be said of large scale cash crop farmers.

Kurukulasuriya and Rosenthal (2003) maintain that the concern with climate change is heightened given the linkage of the agricultural sector to poverty. In particular, it is anticipated that adverse impacts on the agricultural sector will exacerbate the incidence of rural poverty whose impacts are likely to be especially severe in developing countries. Stampini and Davis (2009) found that non-farm employment participation by households is significantly related to more expenditure on seeds, agricultural services, hired labour and livestock inputs. Similarly, Lamb (2003) used household survey data to examine fertilizer use, risk and off-farm labour in

semi-arid tropics of India and found that fertilizer demand increased with the depth of the off-farm labour market. The findings suggest some complementarities between the off-farm labour market and own farm production. This is similar to the findings of the study carried out in Kitui where agriculture and livestock production were the main economic activities which employed a big portion of the labour force in the district. They also account for the largest portion of household and district income. In such a situation where agriculture is the main source of household income for the majority of the people in the district, it is important that the sector is given first priority so that it can improve incomes in the household which will in turn result in an improvement in district income and household food security.

The level of education of farmers was found to be very significant and had an enormous effect on agricultural production. In this study, more than half of the respondents had only attained the primary level of education which is the basic level in the education system. This does not however mean that they had all completed primary education. Some had dropped out of primary school before completing, which meant that their level of education was very low. A small percentage of the respondents had attained tertiary education. Kitui district is generally ranked among the low performers in the country with a low education standard. The low standards of education in the district are attributed to numerous factors among them being: low enrolment, low transition, retention and completion rates and low illiteracy levels among parents leading to complacency. The low education standards impact very negatively on all sectors which affects the economic development in the district (GOK, 2009a). Improving farmers' knowledge of new techniques and technologies, in addition to providing them with any physical resources necessary for implementation, can dramatically increase the farmers' level of productivity (Rosegrant& Cline, 2003). The level of education of the household head has an effect on the total agricultural output produced on the farms (Deressa and Hassan, 2009). This is because agriculture entails more than just tilling the land and planting the seed in the soil. Farmers require skills on the amount and type of fertilizers, the type of seeds, the timing of the growing season, and care for the crops while still in the farm among other skills.
The size of the farm is another factor that determines the level of income and food security in the rural areas. The amount and quality of land owned by the farmers vary from place to place and determines the use to which the land would be put. 27% of the farmers owned less than one acre of land, 60.5% owned more than one but less than five acres of land. This implies that a large portion of the farmers in the study area were small scale farmers who relied almost entirely on their farms for their livelihood. The respondents used the land for both crop production and animal rearing. Food production can be increased extensively through expansion of areas under cultivation (Najafi, 2003). Therefore, in the case of subsistence agriculture, farm holding size is expected to play a significant role in influencing a household's food production and security. Small holder farmers make up majority of the world's poorest people who cannot meet their most basic needs for sufficient food every day (Ludi, 2009). She further notes that of these, the largest segment are the 800 million poor women, men and children who belong to indigenous populations and who live in rural environments and try to make a living as subsistence farmers. In the study area, many of the farmers owned small farms while at the same time relied on rainfall for their agricultural activities and were therefore not able to put their farms into productive usefulness all year round especially during the dry season

CONCLUSION

From the results presented, it can be concluded that agricultural production in Kitui District has reduced due to many factors, with climate change being one of the main causes of the reduction. Average temperature is increasing while the frequency and reliability of rainfall has declined. The study shows that the area has been experiencing high rainfall variability which makes it very unpredictable and unreliable agriculturally. Due to reduced rainfall and increasing temperature, the amount of agricultural production has reduced drastically making

the district food insecure. Droughts have become more frequent and severe with devastating effects on crop and livestock production which has affected household food security. Floods are also experienced as a result heavy rainfall which falls within a short period resulting in large surface run off.

Developing countries have particularly been hard hit by global warming because they are already experiencing high temperatures and low and fluctuating precipitation. This is also because the economies of these countries are highly dependent on agriculture while adoption of modern technology is low. Apart from climate change, other factor responsible for low agricultural production include small farm sizes, low levels of education resulting in low application of technology, lack of other sources of income among others.

There is need to control the rate of GHG emissions into the atmosphere so as to slow down the rate of climate change. Various measures should be put into place so as improve agricultural practices and food production especially in the third world countries.

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