International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 6 Number 8 (2017): Pages 924-939
ISDS Article ID: IJDS17061702

Rainfall and temperature variability and its effect on food security in Kitui county, Kenya

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Abstract

This paper examines the effect of temperature and rainfall variability on agricultural production and food security in Kitui County. A scrutiny of the climate in 30 years (1981 to 2011) revealed a large variation in the rainfall and temperature experienced, which have resulted from the changing climate whose effects have been negatively felt in the economic sector of the region. Rainfall and temperature data were obtained from Kenya Meteorological Department. Data was also obtained using other methods such as questionnaires, oral interviews, FGD and direct observation. Rainfall data was analyzed using rainfall anomaly index (RAI) so as to gauge the long-term changes in climate. Temperature trend for 30 years was also determined with the aim of ascertaining the changes that have occurred. The results show that the changing climate has had a negative effect on food production and water availability; the temperatures are increasing, extreme climatic conditions such as drought have become more frequent and severe while the amount and frequency of rainfall has reduced considerably leading to household food insecurity. The study recommends measures which need to be put in place so as to reduce the negative effects of climate change among them drilling wells for irrigation, planting trees, planting drought tolerant crops and water harvesting among other measures.

Keywords: Rainfall Variability; Temperature Variability; Climate Change; Food Production; Food Security

Cite this article as: Gladys, K.V. (2017), "Rainfall and temperature variability and its effect on food security in Kitui county, Kenya", *International Journal of Development and Sustainability*, Vol. 6 No. 8, pp. 924-939.

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1. Introduction

Climate change has become a reality now and its effects are being felt everywhere. Globally, increasing evidence of changing climate due to rising carbon emissions and other greenhouse gases (GHG) into the atmosphere are being observed everywhere. It is widely projected that as the planet warms, climate and weather variability will increase with unpredictable consequences in different parts of the world. Changes in the frequency and severity of extreme climate events and in the variability of weather patterns will have significant consequences for human and natural systems (Thornton et al., 2014). For the poor countries in the tropics and subtropics particularly, almost every observation and prediction about health, food security, water shortage, natural disasters, famine, drought, and conflict is worsening at an alarming rate (Liverman 2009). IPCC (2012) predicts that increasing frequencies of heat stress, drought and flooding events are anticipated for the rest of this century, and that these are expected to have many adverse effects over and above the impacts due to changes in mean variables alone.

Kenya is susceptible to climate-related effects and extreme weather events pose serious threats to the socio-economic development of the country (GOK, 2013). Climate change poses threats to the attainment of Vision 2030 objectives in the country. Droughts and floods in particular are having devastating consequences on the environment, society and the wider economy (GOK, 2013).

Agriculture is the main economic activity that is carried out by a large majority of Kenya's population both directly and indirectly. It is estimated that agriculture employs approximately 75% of Kenya's population while at the same time contributing about 26% of the country's gross domestic product (GDP) (GOK, 2015). Kenya's agriculture is primarily rain-fed implying that it is very susceptible to any changes in the weather conditions. Tubello et al. (2008) also affirms that agriculture is a fundamental human activity at risk from climate change in coming decades. At the same time it will continue to be a major agent of environmental and climate change at local, regional and planetary scales because it is a major user of water.

With increasing temperatures and erratic rainfall, Kenya's agricultural productivity is projected to face a decline despite the fact that most of the country's population depend on it for food and their livelihood. The impact of weather and climate variability and change is more remarkable in the arid and semi-arid lands (ASALs) (Omoyo et al., 2015) which constitute a large proportion of Kenya. Edame et al. (2011) also report that in most countries where agricultural productivity is already low and the means of coping with adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic. They further report that agricultural productivity in Africa, Asia and Latin America is expected to decrease by as much as 20% (Edame et al., 2011).

Kitui County is one of the semi-arid counties in Kenya which is faced with serious water scarcity challenges. The frequent droughts experienced have led to a reduction in water supply which has subsequently led to the drying of many of the seasonal rivers. The County is mostly dry and hot with temperatures ranging 14°C during the coldest months (July-August) and 34°C during the hottest months (January-March) (CGK, 2014). The county receives between 500mm and 1050mm of rainfall annually, with average rainfall of 900mm a year. It has two rainy seasons; May-June (long rains) and September-October (short rains). Small scale farming is practiced in the entire county while large scale farming is emerging with regard to Sorghum and green grams in some parts. (CGK, 2014).

A study carried out in the County showed that rainfall variations experienced have affected agricultural production with most of the respondents reporting a decline in agricultural production and livestock numbers (Khisa et al., 2014). They further observed that the most severe losses occurred during the prolonged droughts which caused all the green vegetation to dry up that subsequently resulted to the death of most the livestock reared. Omoyo et al. (2015) concur with (Khisa et al., 2014) that the constraints posed by climate change on agriculture range from pronounced seasonality of rainfall to severe and recurrent droughts. GOK (2013) also reports that Kenya is susceptible to climate-related effects and extreme weather events pose serious threats to the socio-economic development of the country. The ASALs are inflicted by a major drought once in every 5 years resulting in widespread food insecurity, poverty, and irreversible decline in herd sizes. The constraints posed by climate change on agriculture range from pronounced seasonality of rainfall to severe and recurrent droughts (Omoyo et al., 2015).

Climate change worsens the living conditions for many who are already vulnerable, particularly in developing countries because of the lack of assets and adequate insurance coverage. It impacts the four key dimensions of food security i.e. availability, stability, accessibility and utilization (Edame et al., 2011).

Agriculture is the main economic activity carried out in Kitui County, yet the county is faced with unpredictable and varying rainfall and temperature conditions making the activity vulnerable to the changing climate. Agriculture is the main source of household food whose outcome affects the small scale farmers income while at the same time exposing them to food insecurity and poverty.

1.1. Scope of the study

This study was carried out in Kitui County which is semi-arid and therefore very vulnerable to changes in the climatic conditions. The study examined rainfall and temperatures of the study area and assessed their variability over 30 years. The study looked at the effect of the rainfall and temperature variability on household food production and food security.

2. Materials and methods

2.1. Study area

This study was carried out in parts of Kitui County located between latitudes 0°10'and 3°0' south and longitudes 37°50' and 39°0' East. Kitui County is one of the 47 counties in the country located about 160km east of Nairobi City. It is the sixth largest county in the country, covering an area of 30,496.4 km^2 including 6,369 km^2 occupied by Tsavo East National park (GOK, 2013). Kitui County has a low-lying topography with arid and semi-arid climate. Its rainfall distribution is erratic and unreliable. The topography of the County can be divided into hilly rugged uplands and lowlands. The altitude of the Kitui County ranges between 400 m and 1800 m above sea level (GOK, 2013) and lowlands. The altitude of the Kitui County ranges between 400 m and 1800 m above sea level (GOK, 2013).

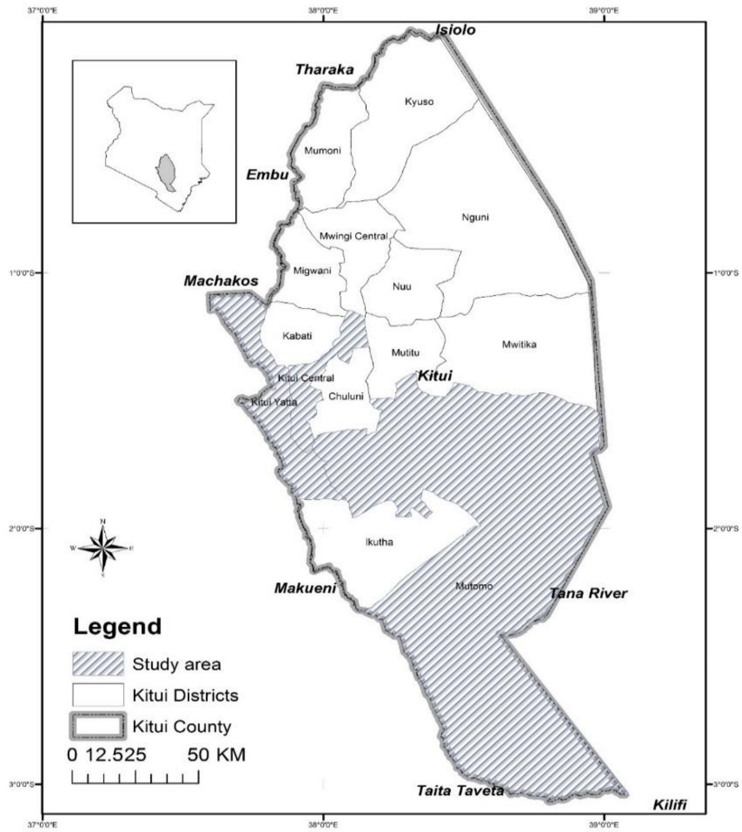

Figure 1. Map showing the study area's position in Kenya

2.2. Climate data

Rainfall and temperature data for 30 years (1981-2011) was obtained from the Kenya Meteorological Department (KMD) in Dagoretti in Nairobi. The data was analyzed using various methods as indicated below:

2.2.1. Rainfall variability and trend

The study analyzed the rainfall received in Kitui County with a view of establishing the long-term changes that had taken place on the rainfall received in the area. These changes were also thought to have an effect on people's livelihood. Results for rainfall variability for 30 years were used as a measure of the rate of climate change due to it being one of the indicators of the climate. Rainfall Anomaly index (RAI) was used to analyze rainfall data. Rainfall anomaly index (RAI) has been commonly used to monitor precipitation in drought-prone regions such as the Brazilian North-east (Hastenrath, 1984; Hastenrath et al., 1984) and West African Sahel (Hulme, 1992).

The construction of RAI involves standardizing the annual or seasonal rainfall total for an individual station by subtracting the station's mean and dividing by its mean (or standard deviation), with the mean and standard deviation being computed from the station's historical record. The rainfall anomaly index for Kitui County was calculated and the results are shows in the figure below.

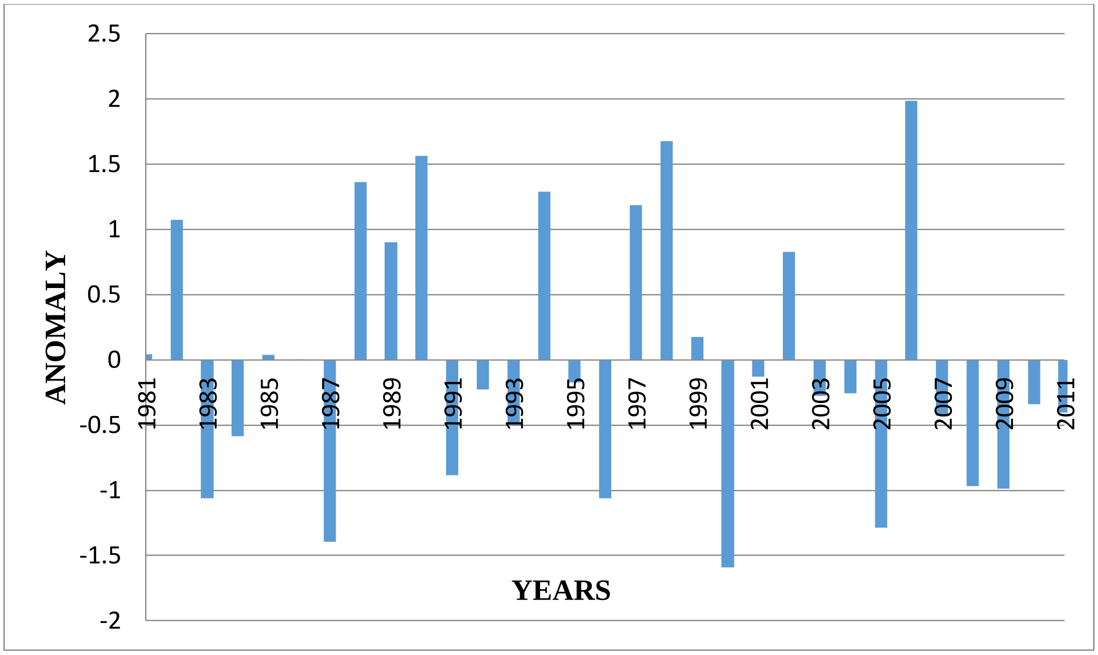

Figure 2. Average annual rainfall variability for Kitui County

Figure 2 shows the rainfall anomalies for the 30 years that were under consideration. It shows that the rainfall received in most of the years was below the mean, except for the years 1982, 1988, 1989, 1990, 1994, 1997, 1998, 1999, 2002, and 2006. The remaining years received rainfall that fell below the mean. The year 1998-1999 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 year 2006 received the highest rainfall.

2.2.2. The rainfall trend

The rainfall data for 30 years was also analyzed to determine the annual average rainfall and the rainfall trend as illustrated in Figure 3. The trend line equation y = 0.0499x + 678.17 indicates the changes that have taken place in the rainfall where 'y' represents the changes in rainfall in millimeters while 'x' represents the slope or the rate of change.

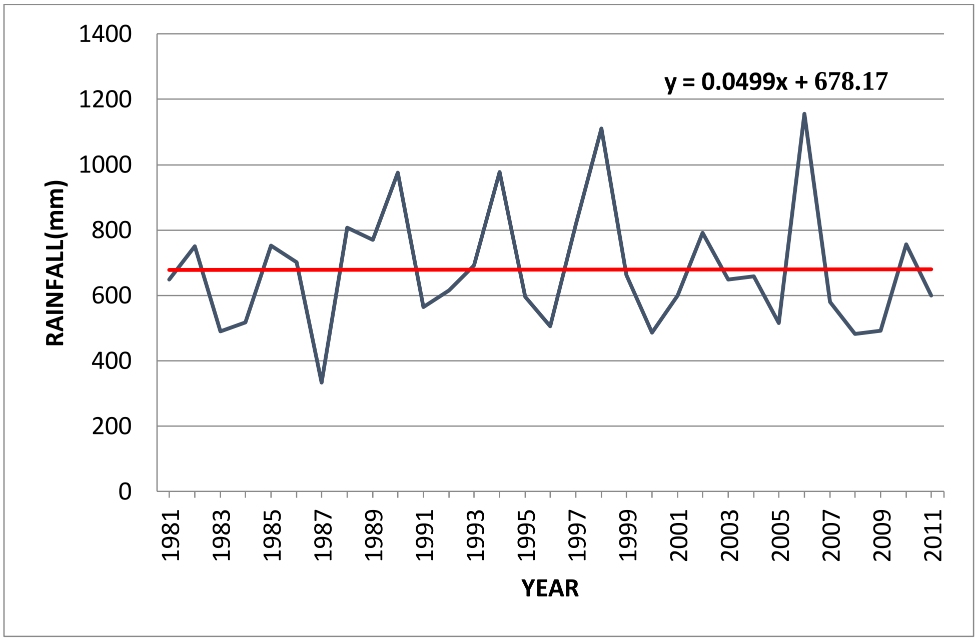

Figure 3. Annual rainfall total and trend for Kitui County

2.2.3. Temperature variation and trend

It is expected that climate change will lead to increase in temperature in some areas and a reduction in other regions. The temperature changes taking place in the study area shown are very small but whose long-time effect has led to an increase in the temperatures experienced. It can therefore be concluded that the average temperature in the region has been increasing over time.

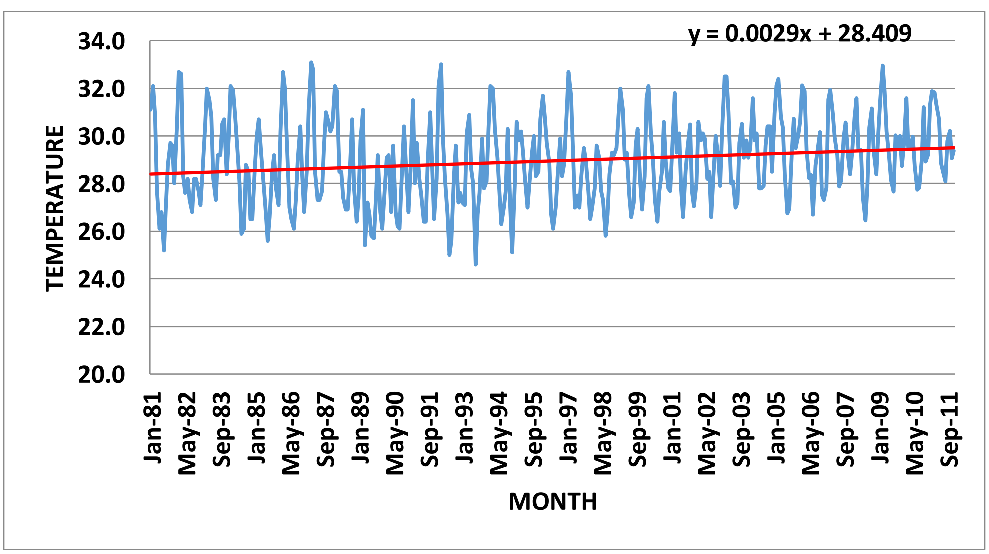

Figure 4. Average temperature variation and trend at a seven month interval in Kitui

In figure 4 above, the temperature trend shows increasing temperatures. Temperatures in the tropics are projected to increase due to increased carbon dioxide in the atmosphere as a result of anthropogenic causes. The increased carbon dioxide has led to the retention of heat in the atmosphere thus increasing the temperatures. As the amount of carbon dioxide increases in the atmosphere, it is expected that temperature in many regions of the world will also increase leading to the hottest temperatures ever experienced. The temperature trend line shows an upward increase in the temperature received in the study area. The temperature trend line $y = 0.0029x + 28.409$ shows changes in temperature where 'y' represents the change in temperature in degrees Celsius while 'x' represents the rate of increase.

3. 3. Results and discussions

3.1. Rainfall variability and trend

Generally, the changes in the amount of rainfall received in a region determines the impact of changes in the climate. It is expected that the wetter regions will get wetter while the drier regions especially those within the tropics will get drier although the magnitude of the changes may not be easily determined.

From the RAI (Figure 2) and the rainfall trend (Figure 3), it can be concluded that dry spell seems to occur immediately after the heavy rainfall leaving questions as to whether there is a relationship between heavy rainfall (1997-1998) and dry spell (1999-2000). Thornton et al. *(*2006) and Conway et al. (2007) report 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 rainfall trend in Figure 3 depicts a downward decline where the rainfall seems to fluctuation annually. It is therefore safe to conclude that the average rainfall in the study area has been declining over time. When looked at keenly, this reduction in rainfall seems small and negligible but if considered over a long period of time, its effect is enormous. The declining rainfall trend can be attributed to the fact that it is a semi-arid region which receives low rainfall and whose rainfall amounts have been declining due to the changing climate.

Hulme (1992) argues that rainfall is one of the most important natural resources for many of Africa's mainland nations. Intra- and inter-annual variability in rainfall is perhaps the key climatic element that determines the success of agriculture in these regions. He further reports that in low rainfall years, there may be drought while in high rainfall years, there may be floods.

The results of this study show that no rainfall was received in 1986, while in 1987 and 1991-1993 the rainfall was far below the average. These results correspond with (WMO, 1995) which reports that extensive droughts have afflicted Africa with serious episodes in 1956-1966, 1972-1974, 1981-1984, 1986-1987, 1991-1992, and 1994-1995 (WMO, 1995).

Ibitoye and Shaibu (2014) agree with (Thornton et al., 2014) that climate is perhaps the most serious environmental threat to the fight against hunger, malnutrition, diseases and poverty in Africa. The effect is manifested mainly through serious reduction in agricultural productivity. Climate change which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa. Ludi (2009) is of the opinion that climatic fluctuations will be most pronounced in semi-arid and sub-humid regions and are likely to reduce crop yields, livestock numbers and productivity. The effects of climate change in Kitui 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 climatic conditions of Kitui County are expected to become more severe with extreme weather conditions like drought becoming more frequent and severe. Hulme (1992) acknowledges that in certain semi-arid regions, persistence in rainfall deviation is significant. He reports that using time series of regional rainfall anomalies showed a striking persistent of Sahelian rainfall anomalies in marked contrasts to East Africa and South-Western Africa. He further reports that it is expected that future weather conditions will become more variable than at present, with increasing frequency and severity of weather extremes globally. Rainfall received has been varying yearly and it is estimated that many of the world's rangelands in the semi-arid areas will have severe water deficits so that any further decline in water resources will greatly impact on the livelihoods and land carrying capacity in these regions (Ludi, 2009). The predictions by Ludi (2009) are similar to the situation in Kitui County which has also been facing water deficit since it is also an ASAL which experiences climatic variability.

As a result of the increased climate variability and droughts, agricultural production in Kitui County is expected to decline drastically. Globally, annual damage from large weather and climate events increased eightfold between the 1960s and the 1990s; between 1980 and 2004, the costs of extreme weather events amounted to US 1.4 trillion (Mills, 2005). While there is considerable regional variation, the relative economic burden of climate extremes as a proportion of GDP is substantially higher in developing countries than it is in developed countries – up to 8% in the most extreme cases (Thornton et al., 2014).

Kitui County has been experiencing declining crop yield which is largely attributed to the changing climatic conditions. Being a semi-arid region, the extreme climate is expected to worsen bearing in mind that the temperatures are getting hotter while the amount of rainfall is also expected to decline further. The area is projected to encounter a reduction in crop yields and livestock numbers just like other ASALs as indicated by Ludi (2009).

Table 1. Correlation between rainfall received and agricultural production

		Agricultural production
Rainfall	Pearson Correlation	.487
	Sig. (1-tailed)	.005
	N	400

In Table 1, the results reveal that there was a weak correlation between changes in rainfall and agricultural production with a correlation coefficient of .487 at a significance level of .005. Despite the fact that the correlation is weak, changes in rainfall have been found to negatively affect agricultural production in many developing countries. The effect may not be very strong but it had a significant effect on agricultural production. The two could therefore be said to be positively correlated in that when one decreased, the other decreased in the same direction and when one increased, the other increased but not necessarily in the same proportion.

In the study area, the respondents indicated that one of the causes of reduced agricultural production was reduced rainfall. The study results concur with Kurukulasuriya and Rosenthal (2003) who indicate that 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. GOK (2013) also reports that the changes in precipitation patterns are likely to directly increase short-term crop failures and long-term production declines for rain-fed agriculture.

The general consensus to emerge from the 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. The study area being a semi-arid region was found to be experiencing low rainfall which has negatively reduced the amount of agricultural produce harvested. Climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions (Ziervogel et al., 2008).

Figure 5 show the fluctuation in maize production in the study area for twenty-six years from 1980 to 2006.

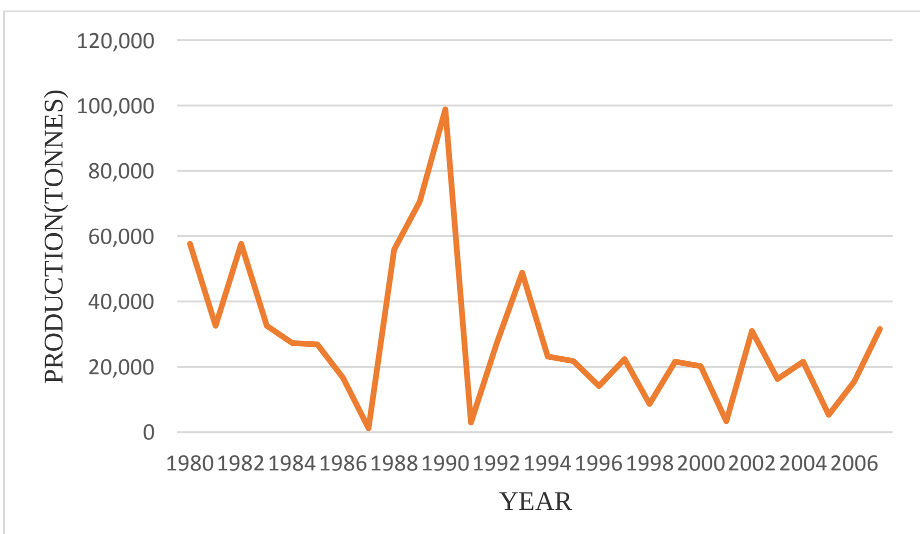

Figure 5. Maize production in Kitui from 1980-2006 (Source: Data obtained from Ministry of Agriculture)

The graph shows a huge fluctuation in the maize production with the highest peak being 1988-1989. These are the years when the study area experienced increased rainfall amounts due to El Nino. It can therefore be concluded that despite the destructive nature of the El Nino rains, it also resulted to an increase in maize production which consequently led to an improvement in food security. The fluctuations can be attributed to the low rainfall received in the region. The study area is an ASAL region which receives fluctuating rainfall, which negatively affects agricultural production (GOK, 2008).

The changes taking place in the climate have been hypothesized to lead to crop failure by many researchers, but most of whom only argue from the negative effects (GOK. 2013). It has been found that apart from these negative effects, positive effects are also expected to be experienced in some regions of the world. Climate change is not always a shift in the mean climatic conditions, but can also exhibit itself as a change in the intensity and frequency of extreme climate events, such as drought, floods, storms, and strong winds, among others (GOK, 2013). GOK (2013) further reports that climate change is closely related to global warming which refers to the general increase in the earth's near surface air and ocean temperatures due to rising greenhouse gas (GHG). Climate change has resulted in reduced rainfall in some areas causing drought while in other regions it has caused too much rainfall which has led to flooding. In arid regions like Kitui, climate change has resulted in long dry seasons which sometimes alternate with too much rainfall that falls within a short time causing floods.

FAO (2010) acknowledges that long term changes in the pattern of temperature and precipitation, that are part of climate change, are expected to shift production seasons, pests and disease patterns. This will modify the set of feasible crops affecting production, prices, incomes and ultimately livelihoods and lives. A similar scenario is expected in the study region brought about by the changing climate.

The results of the study carried out in Kitui 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.

Herero et al. (2010) acknowledge that Kenya is endowed with diverse and abundant climatic resources which provide life-supporting goods and services but which are not evenly distributed throughout the country with some regions being better endowed with more of a particular resource than others. Rainfall also replenishes the dams that are used to produce the country's hydroelectric power. Herero *et al.,* (2010) further reports that most of the streams that flow downstream into the dams that are used for hydropower generation originate in the country's highlands, some of which receive more than 1000 mm of annual rainfall.

The study results from Kitui show that rainfall fluctuations are experienced frequently with some years recording high while others recording very low (almost zero) rainfall. Apart from the fluctuating rainfall, lack of knowledge on coping and adaptation strategies is seen as one of the causes of food insecurity in the study area because most of the farmers depend on rain for their agricultural activities (Khisa et al., 2014a). These results concur with Ludi (2009) that a number of countries in sub-Saharan Africa already experience considerable water stress as a result of insufficient and unreliable rainfall, changing rainfall patterns or flooding. Ludi (2009) further notes that the impacts of climate change including predicted increases in extremes are likely to add to this stress, leading to additional pressure on water availability, accessibility, supply and demand. Khisa et al. (2014a) mirror (Ludi, 2009) that the study area experiences weather extremes which has also resulted in a lot of pressure being exerted on water demand and supply resulting in conflict in some regions.

Kenya experiences a bimodal seasonal rainfall pattern because it lies astride the equator. The long rains season starts around March and runs through to June, with the peak centred in March to May; the short rains run from September and taper off in November or December coinciding with the shifting of the Inter-Tropical Convergence Zone (Herero *et al.,* 2010). They further acknowledge that Kenya experiences major droughts every decade and minor ones every three to four years. In recent years, critical drought periods in the country were experienced in 1984, 1995, 2000 and 2005/2006 (UNEP/GOK 2000) with the most recent occurring in 2017.

Figure 2 confirms this by the low (almost zero) rainfall received during the years 1991, 1995, 2000 and 2005 which are the periods when UNEP/GOK (2000) reported that the country experienced drought. Kenya Red Cross (2009) also agrees with (UNEP/GOK 2000) and reports that Kenya faced a major drought in 2009 that affected all regions, leading to hunger and starvation of an approximate 10 million of people countrywide after a poor harvest, crop failure and rising commodity prices. Reid *et al.* (2004) acknowledges that the impacts of these droughts on the population are increasing due to high population growth and increasing encroachment of agricultural activities in the ASALs. The ASALs are intensifying, and changing from rangeland to mixed systems. This transition from pastoralism to mixed farming is ongoing in many places throughout (Reid et al., 2004, 2008). It is feared that the transition may lead to underground water stress if it is associated with irrigation.

Ludi, (2009) estimated that for Africa, 25% of the population (approximately 200 million people) currently experience water stress, with more countries expected to face high risks in the future. This may, in turn, lead to increased food and water insecurity for the populations.

The study findings also concur with Shongwe et al. (2010) and IPCC (2007) that there has been a 25 percent decrease in rainfall across large portions of the Sahel over the past 30 years. They further report that Southern and Eastern Africa also had more intense and widespread droughts, while Central Africa experienced increased rainfall and less severe droughts. IPCC (2007) argues that although increased precipitation generally has beneficial implications for agricultural production, it may also have negative impacts caused by the increased frequencies and intensities of extreme events like floods. The unpredictability of Kenya's rainfall and the tendency for it to fall heavily during short periods are also likely to cause problems by increasing the occurrences of heavy rainfall periods and flooding (Osbahr and Viner, 2006).

3.2. Temperature variability and trend

Studies indicate that temperatures have generally risen throughout the country, primarily near the large water bodies (King'uyu et al., 2000; GOK, 2010). Other projections also indicate increases in mean annual temperature of 1° to 3.5°C by the 2050s (SEI, 2009). In the study area, temperatures are reported to be rising as result of the changing climate. The country's ASALs have also witnessed a reduction in extreme cold temperature occurrences (Kilavi, 2008). This warming is leading to the depletion of glaciers on Mount Kenya (IPCC, 2007; UNEP, 2009). The study area has been experiencing perennial water shortage which seem to worsen due to the changing climate. Osbahr and Viner (2006) explain that increases in temperatures would have a significant impact on water availability, and are thus expected to exacerbate the drought conditions already regularly experienced and predicted to continue.

The findings of this study show that the temperature is rising leading to hotter days. This is confirmed by (Hulme et al., 2001; Christensen et al., 2007) who report that the climate of Africa is warmer than it was 100 years ago and model-based predictions of future greenhouse gas (GHG) induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate. Observational records show that during the 20th century, the continent of Africa had been warming at a rate of about 0.05°C per decade with slightly larger warming in the June–November seasons than in December–May (Hulme et al., 2001).

Ochola (2009) argues that 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. 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.

Plate 1. A bare land with scattered dry grass due to lack of rainfall and high temperatures in Lower Yatta Sub county, Kitui

Johnes and Thornton (2009) indicate that various studies estimate that warming and drying may reduce crop yields by 10 to 20% overall by the middle of the century, and increasing frequencies of heat stress, drought and flooding events will result in yet further impacts on crop and livestock productivity. They report that the local effects of climate change may be severe in places, to the point where the existing livelihood strategies of rural people may be seriously compromised. Adame et al. (2011) report that the impacts of mean temperature increase will be experienced differently, depending on location (Leff et al., 2004). For example, moderate warming (increases of 1 to 3 ºC in mean temperature) is expected to benefit crop and pasture yields in temperate regions, while in tropical and seasonally dry regions, it is likely to have negative impacts, particularly for cereal crops. Warming of more than 3 ºC is expected to have negative effects on production in all regions (IPCC, 2007). This may explain why the study area is facing chronical food shortages forcing the rural population to depend on food aid.

IPCC (2001) report that by the year 2000, the five warmest years in Africa had all occurred since 1988, with 1988 and 1995 being the two warmest years. Plate 1 shows one of the effects of reduced rainfall and increased temperature which results in most of the vegetation drying up leaving behind bare land.

3.3. Farmers' perspective on rainfall and temperature changes in the study area

The farmers who formed the study respondents were asked whether they had noticed any changes in the rainfall and temperature experienced in the area for the last thirty years. About 356 (89%) of the respondents admitted to have noticed a reduction in the rainfall received in the region. 9.2% (37) of them reported not to have noticed any changes in the rainfall received. A few of them 1.8% (7) did not remember whether the rainfall had changed in the last 10 years or a longer period. Concerning temperature, 96% (384) of them reported to have noticed an increase in the temperatures experienced in the study area while only 1.75% (7) and 2.25% (9) had not noticed any changes and were not sure respectively (Table 2)

Table 2. Changes in the temperature and rainfall

Attribute	Response	Frequency	Percentage
Noticed changes in rainfall	Yes	356	89
	No	37	9.2
	Not sure	7	1.8
Noticed changes in temperature	Yes	384	96
	No	7	75
	Not sure	9	2.25

The findings of the study show that 89% (356) and 96% (384) of the respondents had noticed changes in the rainfall and temperatures received in the area respectively. Only 1.8% (7) and 2% (9) were not sure if there had been changes in rainfall and temperature experienced respectively. The fact that most of the respondents had noticed changes in temperature and rainfall received implies that the climate has changed and is still changing which will have severe implications on the rainfall and temperature experienced which will subsequently affect water availability, agriculture production and household food security.

4. Conclusion

The rainfall and temperature trends confirm that rainfall has been decreasing while temperature have been increasing although the annual changes were very small.When looked at in terms of climatic changes which are calculated after 30 or more years, then the changes can be very significant with the effect being felt particularly in the agricultural sector which is the main driver of the economy of the area. The study area is experiencing changes in the temperature and rainfall which have had a negative effect on agricultural production and food security.

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