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Full Length Research Paper

The changing rainfall pattern and the associated impacts on subsistence agriculture in Laikipia East District, Kenya

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Farmers in Laikipia East District of Kenya rely on subsistence agriculture as their livelihood source which in turn depends on the amount and distribution of rainfall. The main growing season occur during the peak rainfall season, that is, between March and May while the secondary growing season occurs between October and December. Annual rainfall trend between 1976 and 2005 showed that rainfall in Laikipia East District increased a condition suitable for the good subsistence agricultural performance. On contrary, subsistence agriculture in the district performed dismally. This was caused by changing rainfall patterns. The annual numbers of rain days declined but the intensity of rain increased. During the main growing season, the number of rain days declined in March and May but remained constant in April. Rainfall intensities declined in March but increased in April and May. The effect of the changing pattern in rainfall on subsistence agriculture was evidenced by decreased growing period and ineffective rainfall with overall negative effects on yields. This paper examines the changing pattern of rainfall and the associated impact on subsistence agriculture in Laikipia East District, Kenya.

Key words: Climate change, rainfall patterns, growing seasons, subsistence agriculture.

INTRODUCTION

One of the consequences of climate change is the alteration of rainfall patterns. The current study examined the changing rainfall pattern the changing rainfall pattern during the main growing season (March, April and May) and the associated effects on subsistence agriculture in Laikipia east District of Kenya. Due to global warming precipitation amount, type and timing are changing or are expected to change because of increased evaporation, especially in the tropics (Ritter, 2006). Although studies have shown a 2% overall increase in global land precipitation (IPCC, 2001), rainfall characteristics have shown considerable variations from region to region with some areas experiencing decline and in others increase in precipitation due to increased extreme weather patterns. Decrease in precipitation has been experienced in the Sahel, Mediterranean, southern African and parts of southern Asia where much of the rains fall as intense storms particularly in the dry areas (Ritter, 2006). A study by Xuebin Zhang and Francis Zwiers, of environment Canada in Toronto revealed that rainfall in Mexico and northern Africa decreased by nearly 70 mm per year in recent years compared to the 1925 rainfall as quoted in Boswell (2007). Wright and Jones (2003) note that rainfall in southwest Australia has declined by 15 to 20% from the late 1960s. On the other hand, significant increase in rainfall of 2.4% per decade was witnessed over the tropical lands during the 20th Century (IPCC, 2001). Similarly, rainfall has increased by up to 50% in parts of northern Europe (Ritter, 2006). Compared to the 1925 rainfall, Canada, Russia and Europe's annual rainfall has increased by 45 mm and in Peru and Madagascar, rainfall has increased by 60 mm annually (Boswel, 2007).

The seasonality, amount, distribution and the timing of

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the rainfall is of particular importance to the population that depends on rain-fed agriculture for their subsistence. But due climate change, the reliability of the rain for agricultural purposes has reduced in the recent years. For instance, despite the Indonesian annual rainfall decreasing by 2 to 3%, marked changes in precipitation patterns have been observed. Case et al. (2008) observes that the wet and dry seasons have changed with an increase in wet season rainfall in the southern region and a decreased dry season rainfall in the northern region of Indonesia. In Iberian Peninsula, Spain, the number of rain days increased over the 20th Century except in the Gulf of Cádiz and in western Portugal. The amount and intensity of rainfall declined in the Peninsula except for the two regions where the intensity increased (PhysOrg.com, 2011). IPCC (2001) indicates that in some parts of the equatorial East Africa December, January and February (DJF) rainfall may increase by 5 to 20% while June, July and August (JJA) rainfall may decrease by 5 to 10% under the lowest warming scenario. Climate change predictions indicates that North Africa will experience a significant decline in rainfall of 10 to 20% between March and November while South Africa rainfall will decrease by 5 to 15% between November and May by 2050.

Agricultural activities follow rainfall patterns especially in tropical regions. In Sub-Saharan Africa rain-fed agriculture, which provides food for the populace and represent a major share of the countries' economy follow precipitation pattern closely (United Nations Environmental Programme, 2008). Therefore, short-term as well as long-term variations in rainfall patterns have important effects on crop and livestock farming (IPCC, 2007). Seasonal rainfall has been marked by delayed onsets, declining number of rain days and increased intensities altering farming calendars with negative effects on the yields. Awuor and Ogola (1997) observed that global warming will likely affect the agricultural productivity due to changes in the length of growing periods. They observed that the length of growing period would increase by about 10 days/°C increase in mean annual temperature in Canadian Praire. In Kenya, they noted that increase in temperature by 4°C will result in a dramatic shortening of the length of the growing period. In Myanmar, Phyu (2010) notes that the monsoon period reduced by about 10 days in 2009 from an average of 144 days. The main growing rainfall seasons which occur in March, April and May (MAM) and December, January and February (DJF) have been declining since the 1980s in Ethiopia, Kenya, Tanzania, Zambia, Malawi, and Zimbabwe (UCSB, 2008). UCSB attributes the declining rainfall to anomalies in moisture transport between the ocean and land due to rising sea surface temperatures over the Indian Ocean.

According to IPCC (2007), changes in rainfall patterns have negatively affected mixed rain-fed and highland perennial systems in the Great Lakes region and in other parts of East Africa. Agriculture has progressively become more marginal in the arid and semi arid areas. A significant decrease in suitable rain-fed agricultural land and production potential for cereals has been predicted under climate change by 2080. For instance, under increased El Niño Southern Oscillation (ENSO), South Africa would experience significant reductions in maize production. On the other hand, a combination of increased temperature and rainfall may result in longer growing seasons in some parts of the Ethiopian highlands and southern Africa such as Mozambique improving agricultural performance. Based on these observations, it therefore follows that rainfall patterns have been changing as climate changes and so has rain-fed agriculture. Thus, for agricultural purposes changes in growing period are very important and must be viewed against possible changes in seasonality of rainfall, onset of rain days and intensity of rainfall. The current study examined the changing rainfall pattern during the long rainfall season (March, April and May (MAM)) which is the main growing rainfall season in Laikipia east District of Kenya since farmers largely depend on this season for subsistence food production. Rainfall during the short rains, which occur in October November and December (OND) is unreliable and inadequate particularly for maize growing, which forms the staple food for the inhabitants.

Objective of the study

The study had two objectives:

1) To analyze rainfall patterns during the long rainfall season which is the main crop growing season?
2) To examine the effects of changing rainfall patterns on subsistence agriculture.

METHODOLOGY

The study focused on the changing rainfall patterns and the subsequent effects on subsistence agriculture. Data for the study was collected in Daiga Division of Laikipia East District which is located in the central parts of Kenya. The district, which lies between longitudes 36°54'' and 37°23'' East and latitudes 0°02'' and 0°27'' North, was curved out from the former Laikipia District in 2009. Daiga Division has an area of 828.8 km^2 with a population density of 40 persons/ km^2. The division is subdivided into Umande, Ethi and Naibor Locations. Rain-fed mixed farming is practiced in Umande and Ethi Locations while pastoralism dominates Naibor Location. Figure 1 shows the location and size of Laikipia East District in relation to the former Laikipia District.

Laikipia East District falls under the semi arid climate with a mean annual rainfall of 637 mm and temperature ranging from 20 to 28°C. Rainfall in the district follows the seasonal movement of the inter tropical convergence zone (ITCZ). This results in two rainfall season, ''the long rains'' which falls between March and May (MAM) and the ''short rains'' which falls between October and December (OND). However, a third rainfall season known as the continental rains is experienced between July and August. The continental

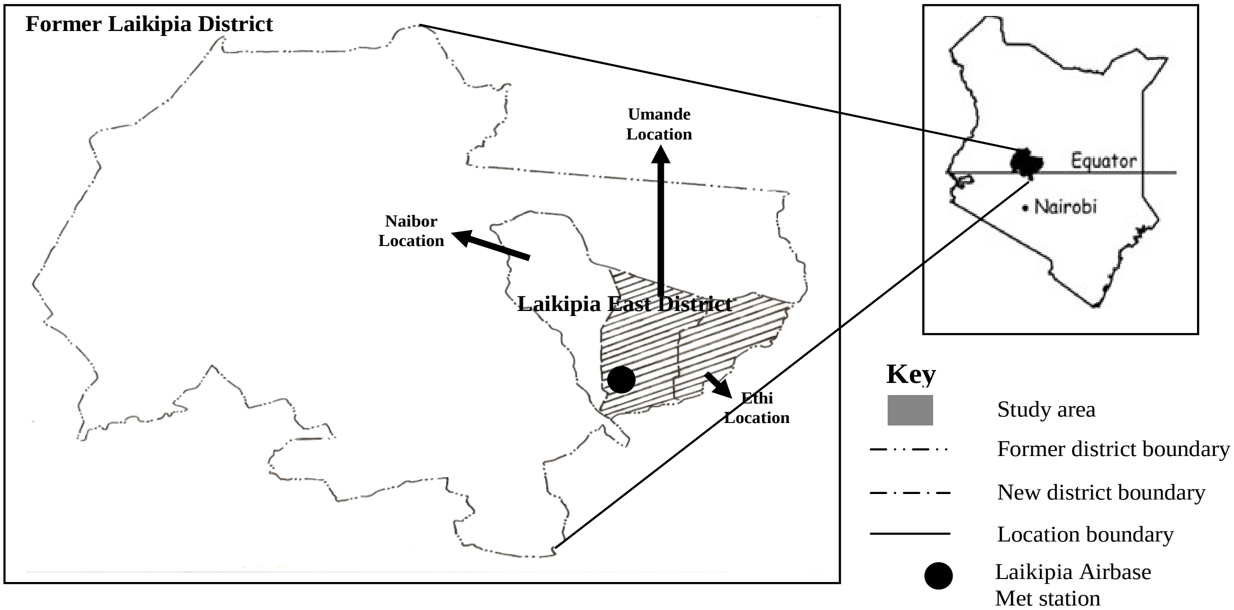

Figure 1. Location of the study area.

rains are caused by the Congo Airstream (Jaetzold and Schimidt, 1983). Farming practices in the district are strongly dependent on rainfall and therefore follow rainfall patterns. MAM is the main growing season while OND is the secondary growing season. The study focused on the MAM rainfall season since it determines the food security situations in the division. Rainfall reliability during this season is 60% (Jaetzold and Schimidt, 1983) and accounts for over 80% of food production in the division. Subsistence rain-fed mixed farming is the main source of livelihood in the district. The dominant crops grown are maize and beans and are planted by all farmers. Others crops include: potatoes which is planted by 82.3% of the farmers, peas (64%), cabbages (50%), kales (50%) and sweet potatoes (37.4%). In addition to crop growing farmers reared cattle, sheep, goats and chicken. Land holdings are small with 83.8% of the farmers owning 2 Ha and below while 16.2% of the farmers owned land holdings of more than 2 Ha.

Mixed farmers from 328 out of 7261 households in Umande and Ethi Locatios of Daiga Division were interviewed. The choice of the two locations was because of dominance of rain-fed mixed farming. Crop yield data, maize and bean yields for a period of 16 years (1986 to 2001), was obtained from Centre for Training and Integrated Research in Arid and Semi-arid Land (CETRAD) offices in Nanyuki, Kenya. The choice of maize and beans was because the two are staple food for the communities living in the study area and are the main crops planted during the MAM season. Rainfall data was obtained from Laikipia Airbase meteorological station, which is situated in Daiga Division, and was used in analyzing rainfall characteristics. To analyze rainfall characteristics, the study examined a 30 year period (1976 to 2005). This period was divided into 3 decades; the 1976 to 1985, 1986 to 1995 and 1996 to 2005 decades. Comparisons of rainfall characteristics were based on the three time periods. Decadal average number of rain days and rainfall intensities were obtained as follows:

$$\bar{x} = \frac{\sum x}{n}$$

Where: x = number of rain days during MAM season in a given decade n = number of years in a decade

$$\bar{x} = \frac{\sum y}{z}$$

Where: y = amount of rainfall during MAM season in a given decade z = number of rain days during MAM season in a given decade.

A rainy day in this study is defined as a day when total rainfall amount was at least 0.85 mm and above.

RESULTS AND DISCUSSION

The changing rainfall patterns

For agricultural purposes, the study analyzed rainfall patterns during the MAM season since subsistence farmers in Daiga Division of Laikipia East District largely depended on these rains. The MAM seasonal rainfall showed an increasing trend but with marked year to year variations during (Figure 2). Decadal analysis of rainfall trends revealed that the mean MAM seasonal rainfall rose from 214.1 mm during the 1976 to 1985 decade to 224.4 mm during the 1986 to 1995 decade and subsequently to 232.1 mm during the 1996 to 2005 decade.

The study established that contrary to the increasing annual rainfall trend, the number of rainy days was declining (Figure 3), an observation that was confirmed by 82% of the respondents. Analysis of daily rainfall data revealed that the number of rain days declined from an

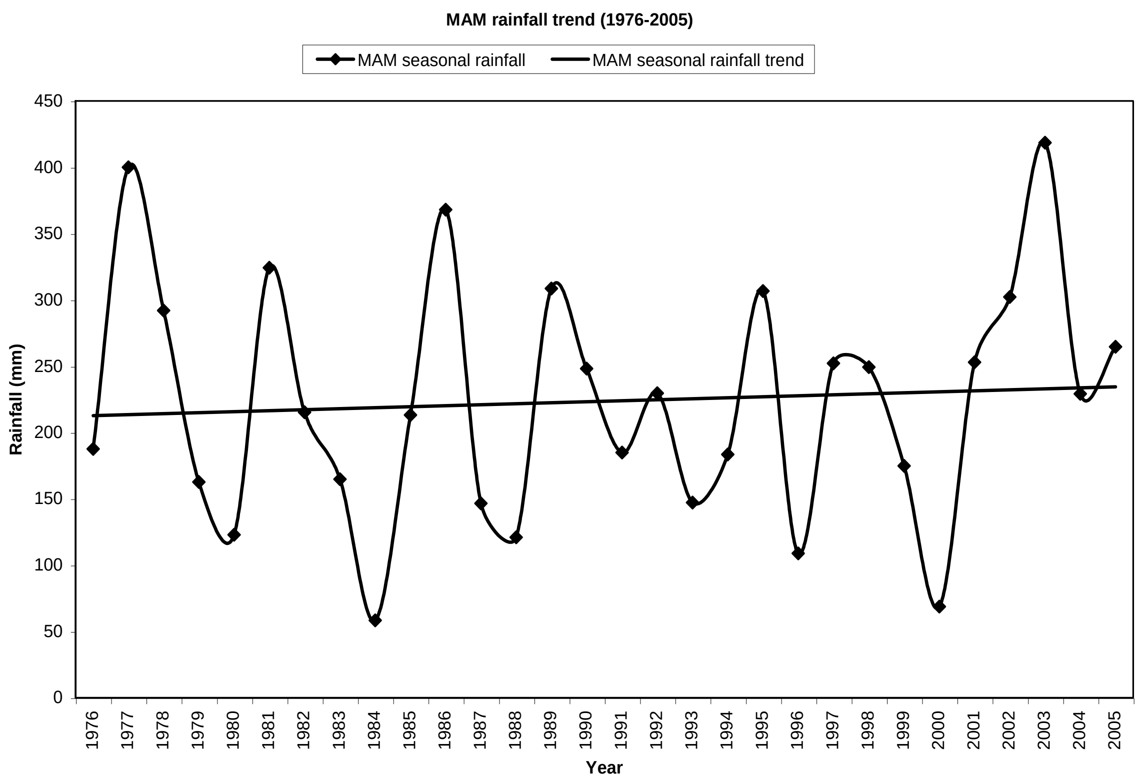

Figure 2. MAM seasonal rainfall trend (1976 to 2005).

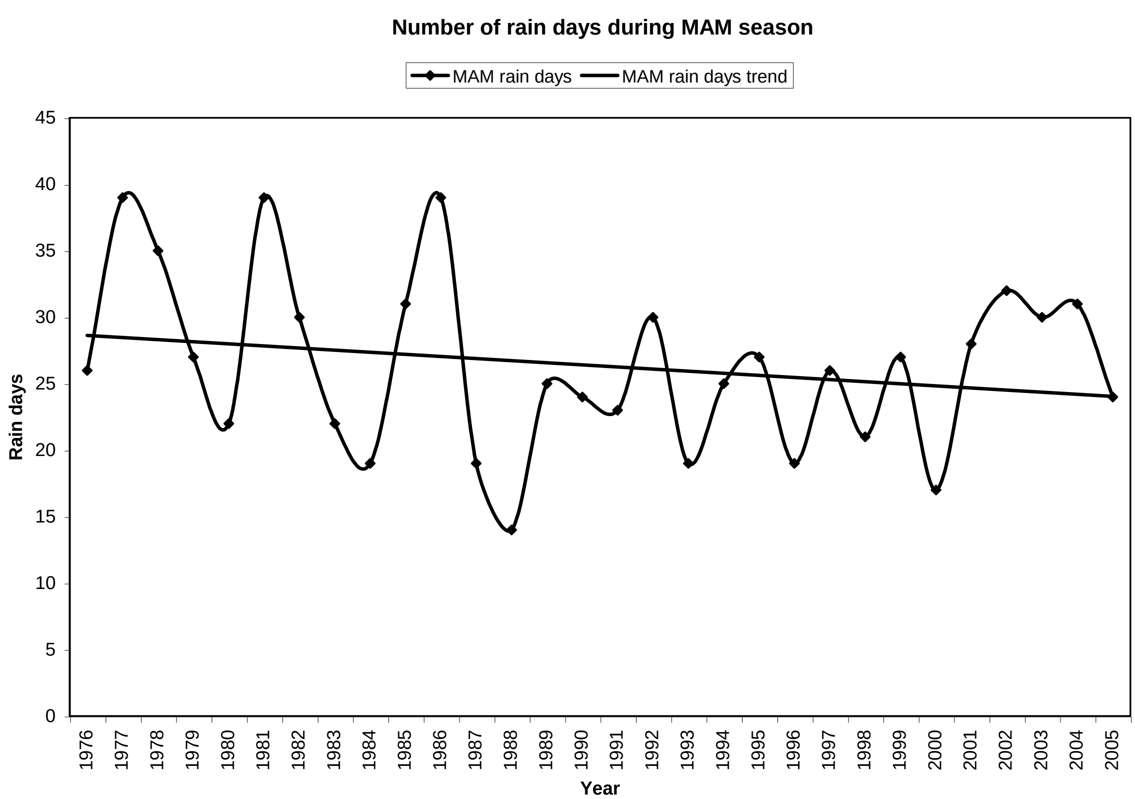

Figure 3. Trend in number of rain days during the MAM rainfall season.

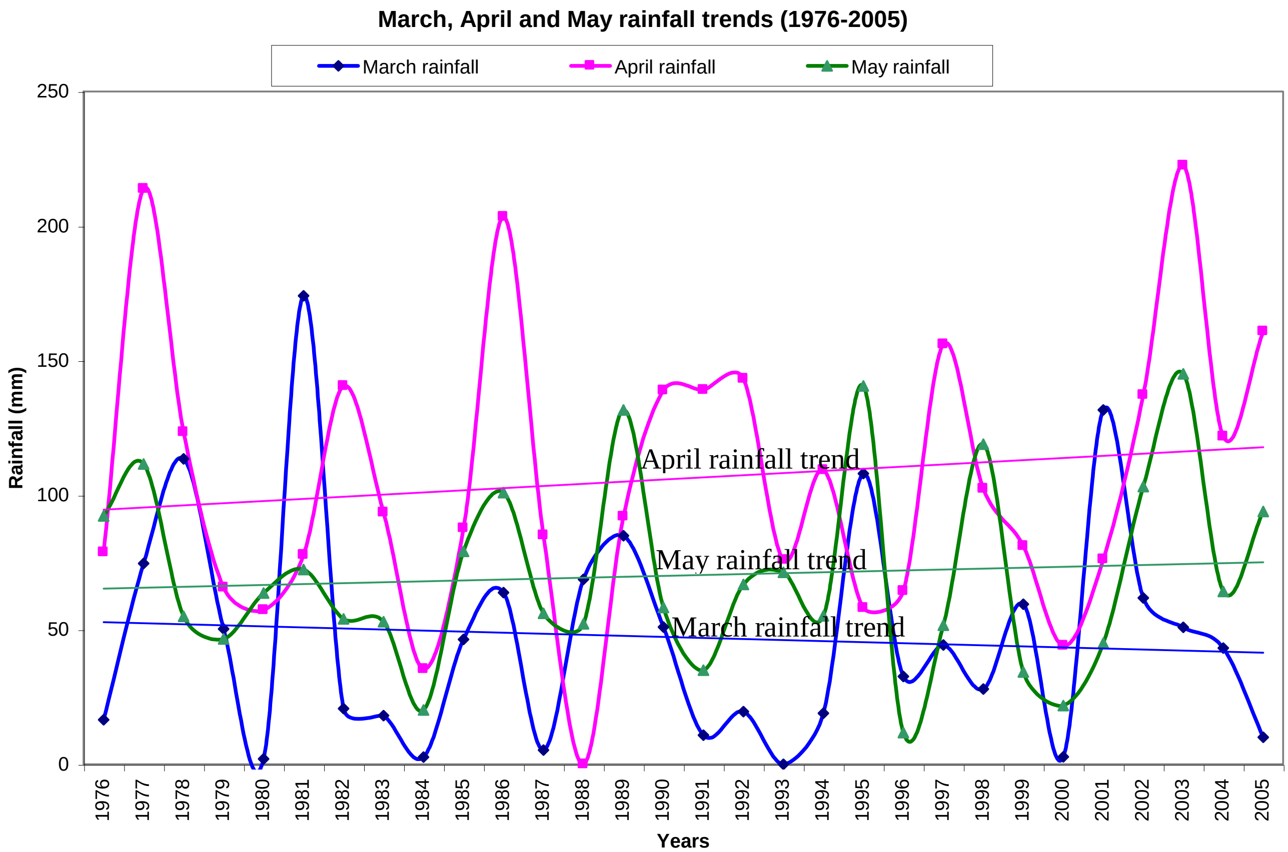

Figure 4. Monthly rainfall trends during the MAM rainfall season (1976 to 2005).

average of 29 rain days during the 1976 to 1985 decade to an average of 26 rain days during the 1996 to 2005 decade. The least number of rain days was recorded during the 1986 to 1995 decade when the district recorded an average of 25 rain days. The coefficient of variation (*Cv*) indicated that the number of rain days was less variable during the 1976 to 1985 decade compared to the 1986 to 1995 and 1996 to 2005 decades. The *Cv*s for the number of rain days were 24.4, 27.9 and 29.6% for 1976 to 1985, 1986 to 1995 and 1996 to 2005 decades respectively. Therefore, the increasing rainfall trend was attributed to increase in high intensity rainfall rather than the number of rain days. Decadal rainfall intensity increased from an average of 7.0 mm during the 1976 to 1985 decade to 8.9 mm during the 1996 to 2005 decade. The findings concur with the IPCC (2007) observation that under the climate change more extreme weather events such as severe storms will be experienced.

Month to month rainfall analysis during the MAM season revealed that rainfall amount declined in March but increased in April and May (Figure 4). During the month of March (the start of the MAM rainfall season) the average number of rain days decreased from an average of 6.1 to 5.8 days between 1976 and 1985 and 1996 and 2005 decades. Rainfall intensity decreased to 6.5 mm during the 1986 to 1995 decade from 7.4 mm during the 1976 to 1985 decade. During the 1996 to 2005 decade, rainfall intensity rose back to 7.4 mm. Overall, the month of March showed no increase in rainfall intensity. Coupled with declining number of rain days, the study established a shift in the onset of the MAM rainfall season, an observation ascertained by 76% of the respondents. Using the definition of the start of rain as the first occasion after the 1st of March with 20 mm or more in 1 or 2 consecutive days (Huho, 2011), the study established delayed onsets of the start of rains in the study area. Figure 5 shows the years when rainfall started in March and the trend for the start of rain date.

During the month of April, the number of rain days decreased from an average of 12.2 to 11.7 days between 1976 to 1985 and 1996 to 2005 decades while rainfall intensity increased from 7.7 to 10.2 mm during the same period. Coefficient of rainfall variation (C*v*) shows that the April rainfall was getting less variable. The C*v* decreased from 52.3% during the 1976 to 1985 decade to 46.3% during the 1986 to 1995 decade. During the same period, the month of May experienced a decrease in the number of rain days from an average of 11.7 to 10.7 days and an increase in rainfall intensity from 5.9 to 8.4 mm. The C*v*

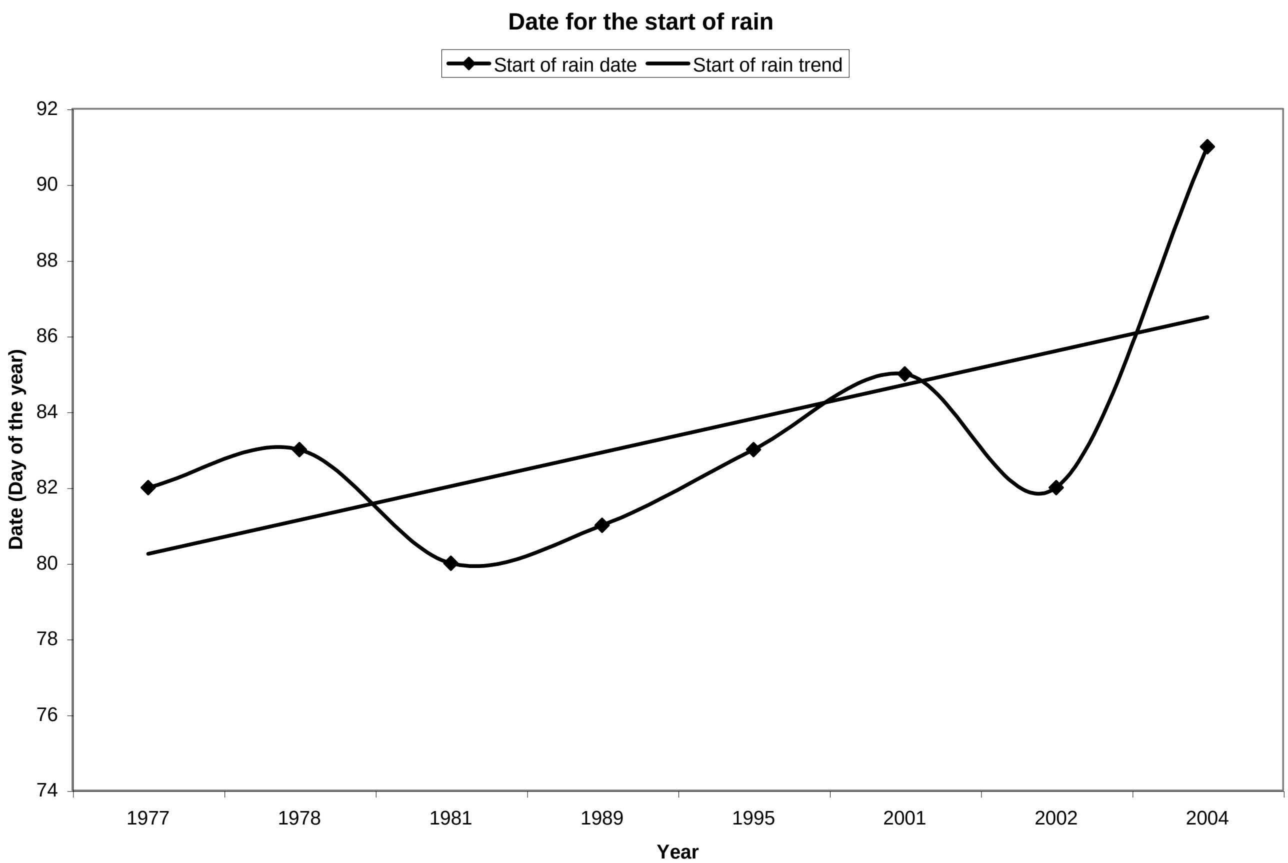

Figure 5. The trend for start of rain date during the month of March (1976 to 2005).

for the May rainfall increased from 39.5% during the 1976 to 1985 decade to 64.2% during the 1986 to 1995 decade. This was an indication that the May rainfall is increasingly becoming erratic and unreliable. The study established that despite the increasing rainfall amounts during the MAM season in Daiga Division of Laikipia East District, the season was getting shorter as climate changes. The conclusion was ascertained by 68% of the respondents who acknowledged that the climate in the division had changed and 70% of the respondents who stated that the length of the MAM growing season had shortened due to inadequate or delayed rainfall onset and early cessation of the rains.

Effects of changing rainfall patterns on subsistence agriculture

Subsistence agriculture in the study area depends entirely on rainfall performance. Although there are other factors such as high costs of production, poor market prices, reduced farm land sizes due to population pressure, which contributed to the decrease in agricultural productivity, changes in rainfall patterns plays the key role since agriculture in the division is purely rainfed. Changes in rainfall patterns alter farming activities with overall negative effects on the final yields. The study established the following effects.

Shortened growing period

Decline in the number of rain days during the MAM season was an indication that the length of the main growing season was shortening. About 80% of the respondents stated that the growing season had shrunk by about three weeks. They stated that the March rainfall amounts had declined and become more unreliable while May rains ended earlier than usual. The delayed onset of rains in March forced some farmers to shift their planting dates to mid March and early April (Huho, 2011). Shorter growing periods in the study area led to changes in crop varieties from crops that had longer maturity periods to those with shorter periods. Citing maize crop as an example, farmers stated that they had replaced hybrid maize of series H511 and 614 which took longer durations (180 to 210 days) to mature with varieties such as Dekalb 8031, 8053; Pioneer 30G19, 30V53, 30G97, 3253; Duma 41, 43, 53; Katumani Composite B; and Western Seed Company 402 and 503 which took shorter

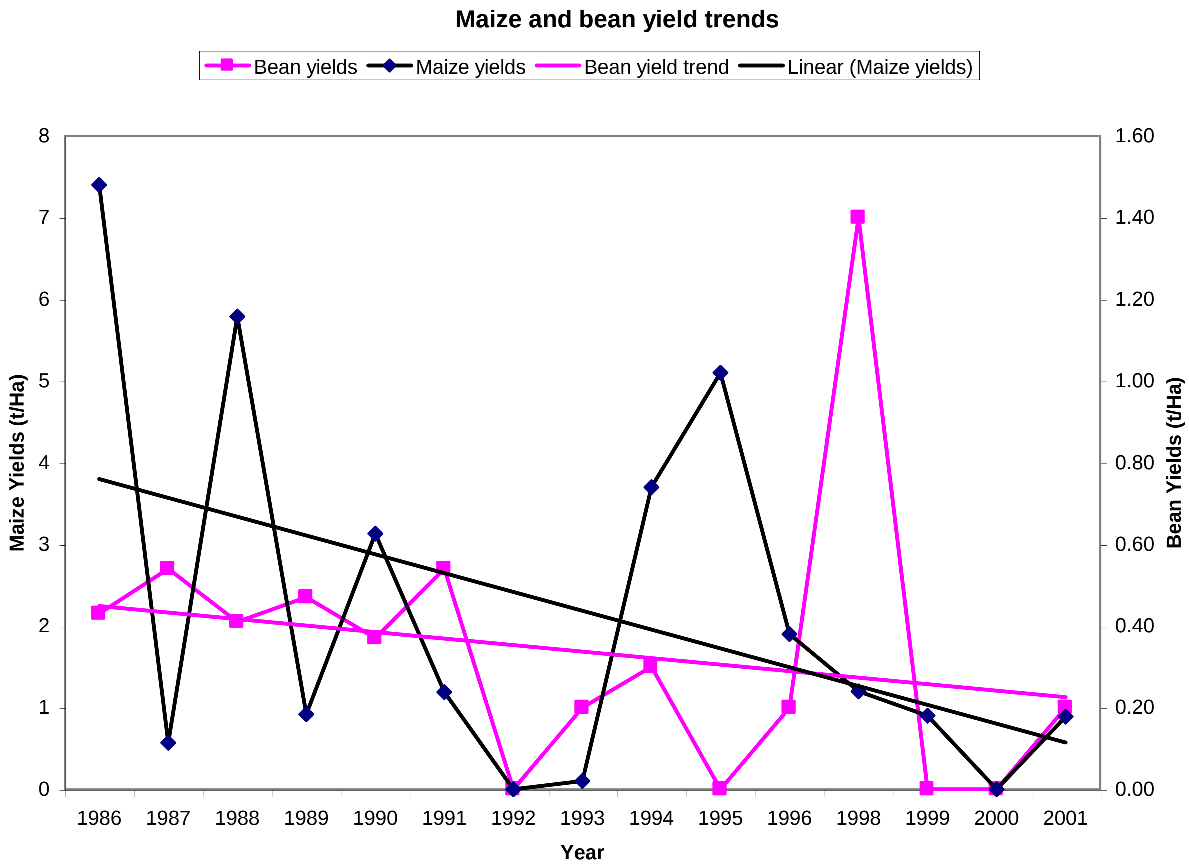

Figure 6. Annual maize and bean yield trends in Daiga Division of Laikipia East District Source: CETRAD, 2002.

growing periods of between 120 and 150 days. However, farmers argued that H511 and H614 varieties yielded more, had weightier grains, and were tastier compared to the new varieties. Thus farmers continued planting these varieties though in less quantities.

Poor yields due to high but ineffective rainfall

The MAM season seemed to have an overall increase in the rainfall (Figure 1), a condition suitable for rain-fed subsistence agriculture. However, the study established that agricultural output had been declining (Figure 6). Asked why they hardly harvested enough yields for subsistence, 60% of the respondents stated that rainfall was poorly distributed during the growing period and that it occurred in form of storm which caused floods that inundated crops and destroyed crop leaves especially if the rains had hailstones. Mwangi, a crop farmer in the study area reported the following:

"…nowadays rain falls in just a few days unlike in the 1970s and in the early 1980s. However, the rains we receive now are very heavy which sometimes inundate the planted fields, washes away the top soil and sometimes destroy farm houses. Most of our lands are infertile because of repeated soil erosion…"

Increasing rainfall variability during the growing season led to droughts during the growing period. About 67% of the respondents stated that early season droughts were common especially when planting was done in early March due to increase in "false rains". They argued that the rainfall that fell at the beginning of March were usually heavy giving a false impression of reliable start of the long rains prompting some farmers to begin planting. However the early March rains had become increasing short-lived and were immediately followed by dry spells that sometimes extended up to two weeks causing poor germination of seeds. To cope with the uncertainty of the early March rains, farmers started planting with the rains that fell from mid March. Only a small number of the respondents (20%) stated that they were affected by mid-season droughts. The study attributed the occurrence of fewer mid-season droughts to the decreasing variability in April rainfall from 52.3% during the 1976 to 1985 decade to 46.3% during the 1996 to 2005 decade. About 84% of the respondents were pessimistic about obtaining good harvests due to late-season droughts, which had increased in the recent years.

Plate 1. Drying maize crops due to late-season drought.

The respondents' assertion was confirmed by the analyzed May rainfall data which shows that rainfall variability during the month of May rose to 64.2% from 39.5% during the 1996 to 2005 and 1976 to 1985 decades respectively. Plate 1 shows the drying maize crops at the beginning of the late season drought in the study area. Karuthi, a farmer in the district stated as follows:

"…having green fields and healthy crops in this district is not a guarantee that there will be a bumper harvest. Many are the years that we've ended up begging for food due to the late-season droughts… Now we are unceasingly becoming a food insufficient society…"

Analysis of rainfall data revealed that the number of rain days in May had been decreasing causing early cessation of the MAM seasonal rainfall. This observation was consistent with respondents' assertion that late-season droughts were on the increase. The increasing variation in May rainfall (C*v* for May) indicated that the rains were becoming more unreliable. In addition, increasing rainfall intensity during this month led to poor crop yields due to destruction of crop leaves and flowers, if rainfall had hailstones, and fell during the flowering and grain filling stages. The observed decline in crop yields confirms the IPCC (2007) assertion that in some African countries climate change will exacerbate the deficiencies in rain-fed agricultural yield by up to 50% during the 2000 to 2020 period.

Low soil fertility was mentioned by 74% of the respondents as a factor that had led to decline in yields. Soil erosion was ranked as the second major cause of declining soil fertility after over cultivation by 60% of the respondents in the study area. Due to the semi arid nature of the district, frequent occurrence of droughts hardens the top soil reducing its ability to absorb rain water when rainfall eventually comes. With hardened top soil, increased rainfall intensities served to increase surface runoff and in turn increased rate of soil erosion. This was evidenced by rills and small gullies on the farmlands and regular silting of the dams and water pans in the study area. According to IPCC (2007) climate change leads to greater soil erosion due to increased rainfall intensity.

Irregular planting dates

Increasing rainfall variability particularly in March made it difficult for farmers to plan for agricultural activities. 84% of the respondents stated that planting dates have increasingly become irregular with planting duration spanning from March to May (Figure 7). Wairimu, a crop farmer in Daiga Division, explained the shifting planting dates as follows:

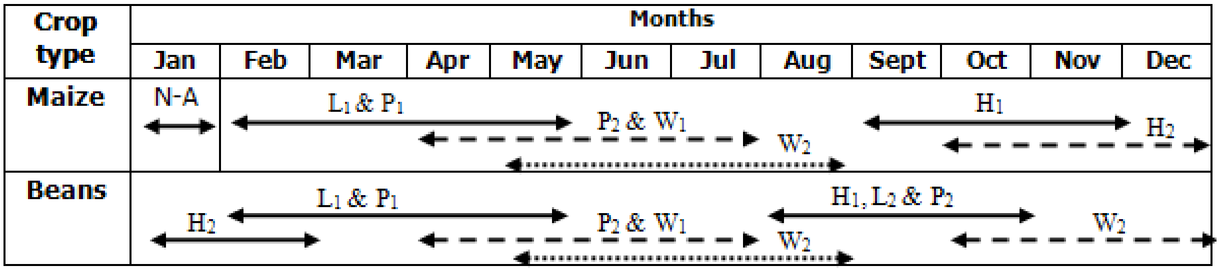

Figure 7. Irregular farming calendar in Daiga Division. L_1 = Land preparation for first cropping cycle; L_2 = Land preparation for second (replanted) cropping cycle; P_1 = Planting for first cropping cycle; P_2 = Planting for second (replanted) cropping cycle; W_1 = Weeding for first cropping cycle; W_2 = Weeding for second (replanted) cropping cycle; H_1 = Harvesting for first cropping cycle; H_2 = Harvesting for second (replanted) cropping cycle; and N-A = No Activity.

"…we used to plant from late February (dry planting) to mid March (wet planting). By mid March, all planting was complete in the 1970s. Today planting begin from mid March through April. It is not uncommon to see people planting in May depending on the reliability of the rains. We cannot talk of a specific planting period nowadays since farmers plant at different times…"

The study established that delays in planting affected all other farming practices such as weeding, spraying and harvesting. About 68% of the farmers stated that alteration of the farming calendar affected labour availability since they depended on their school going children for weeding during school holidays in April. Shifts in weeding seasons to May or June meant shortage of farm labour because children were back in schools for their second term. In addition to inadequate labour, farmers also stated that the declining June rainfall led to mid or late season droughts leading to frequent crop failures.

Conclusion

Although subsistence agricultural production in Laikipia East District has been affected by a myriad of factors such as escalating costs of farm inputs, poor market prices and reduced arable lands due to land fragmentations caused by population increase, changes in rainfall patterns is the major contributing factors. Changes in rainfall patterns are evidenced by the declining number of rain days in March and May, increasing rainfall intensity and rainfall variability. Shifts in timings of rainfall onset has led to altered planting dates and shortened growing periods with the overall effect on final yields and hence continued food insecurity in the district.

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