3. Results and Discussion

3.1 The changing rainfall patterns and trends

Decadal analysis of rainfall trends revealed that the mean MAM seasonal rainfall rose from 203.2mm during the 1983 to 1992 decade to 229.7mm during the 1993 to 2002 decade and subsequently to 346.1mm during the 2003 to 2013 period, an observation that was confirmed by 84.8% of the respondents.

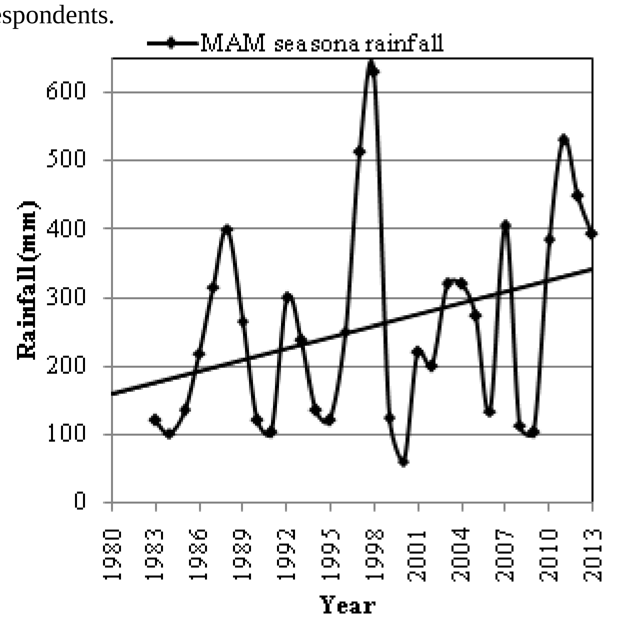

Figure 2: Rainfall Patterns

It is evident from Figure 2 that 1997/98 years experienced the highest amount of MAM rainfall in Chepareria division. This coincides with the *El Niño* rains experienced throughout the country during the same time. Similarly, Senetwo location experienced the lowest MAM rainfall in the year 2000 with only 60mm of rainfall collected. This is also the time during which the country experienced a major drought, the La Nina effect (Shisanya *et al.*, 2011). The 2000 and 2009 droughts were the worst in at least 60 years (Huho, 2011), and between these two extreme years, several other rainy seasons have failed. The increasing rainfall trend was attributed to the increase in high intensity rainfall rather than the number of rain days. The study also established that contrary to the increasing annual rainfall trend, the number of rainy days was declining (Figure 3).

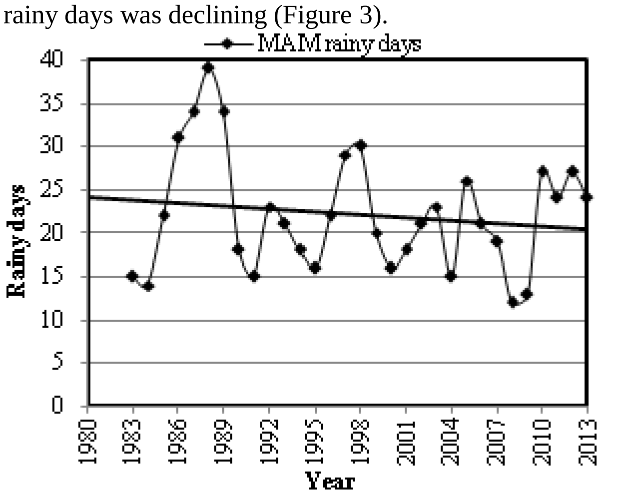

Figure 3: Rainy days

Analysis of daily rainfall data revealed that the number of rain days declined from an average of 25 rain days during the 1983 to 1992 decade to an average of 21 rain days during the 1993 to 2002 period and the least number of rain days was recorded during the 2003 to 2013 decade when the location recorded an average of 20 rain days. The coefficient of variation (*Cv*) indicated that the number of rain days was more variable during the 1983 to 1992 decade at 37.9% compared to the 1993 to 2002 decade at 23.2% and the 2003 to 2013 period at 26.3%, accordingly. Decadal rainfall intensity increased from an average of 8.5mm during the 1983 to 1992 decade to 11.8mm during the 1993 to 2002 decade, and a further increase to 14.8mm during the 2003 to 2013 period. 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).

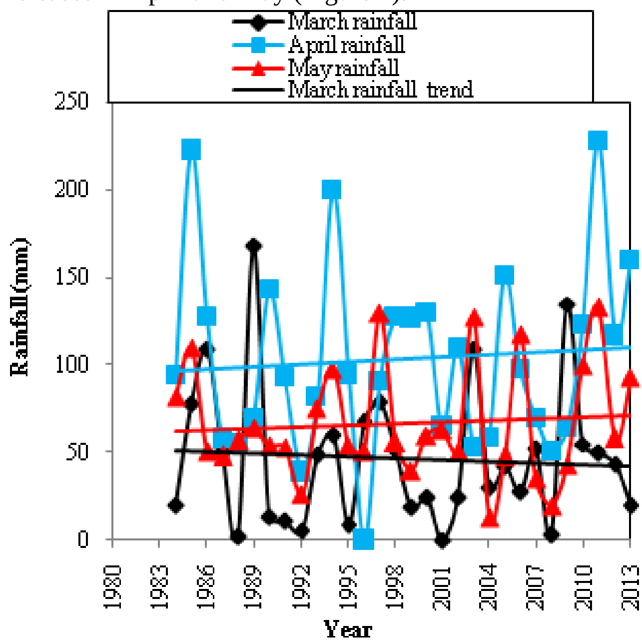

Figure 4: Month to month rainfall

During the month of April, the number of rain days increased from an average of 7.1 days to 8.2 days between 1983 and 1992 while 2003 to 2013 periods; rainfall intensity increased from 12.6mm to 14mm during the same period. Coefficient of rainfall variation (C*v*) shows that the April rainfall was getting more variable. The C*v* increased from 52% during the 1983 to 1992 decade to 75.5% during the 1993 to 2002 decade but again became less variable between 2003 to 2013 period with a C*v* of 58.9%. During the same period, the month of May experienced an increase in the number of rain days from an average of 7.4 to 9.5 days and an increase in rainfall intensity from 12mm to 15.2mm. The C*v* for the May rainfall increased from 57.7% during the 1983 to 1992 decade to 66.7% during the 1993 to 2002 decade. A decline in C*v* to 59.9% for May rainfall during 2003 to 2013 period was an indication that the May rainfall is decreasingly becoming consistent but reliable.

Coupled with declining number of rain days, the study established a shift in the onset of the MAM rainfall season

(Figure 5), an observation ascertained by 88% of the respondents. Using the definition of the start of rain as the first occasion after the 1st of March with 20mm 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. The study established that despite the increasing rainfall amounts during the MAM season the rainy season in Senetwo Location was getting shorter as climate became more variable. This conclusion was ascertained by 80% of the respondents who acknowledged that the climate in the area had changed.

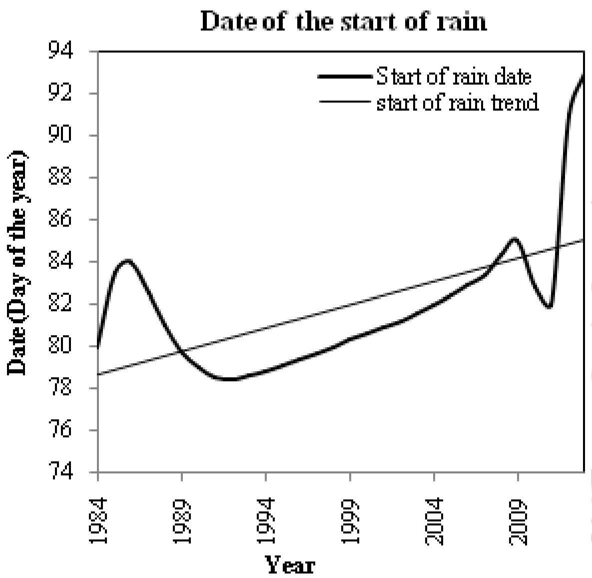

Figure 5: Onset of the rain season

3.2 Effects of changing rainfall patterns on smallholder agriculture

Subsistence rain-fed agriculture in the study area is a major livelihood option and 'unfortunately' depends entirely on rainfall performance. The dominant crops grown are maize and beans and are planted by all farmers. Other crops grown include millet and sorghum 28%, bananas 11.2%, and cassava 5.6%. In addition to crop growing farmers reared cattle (94.4%), sheep (79.2%), goats (70.4%) and chicken (98.4%). The average land size per household is about 5 acres with some households having as much as 12 acres and others with as little as 0.8 of an acre.

Although there are other factors such as high costs of production, poor market prices, reduced farm land sizes due to population pressure, which can also contribute to the decrease in agricultural production, changes in rainfall patterns play the key role since agriculture in the study area is purely rain fed. Changes in rainfall patterns therefore alter farming activities with overall negative effects on the final yields (Huho, 2011). The study thus established the following effects.

3.2.1 Shortened growing period

Decline in the number of rain days and the increase in rainfall intensity during the MAM season was an indication that the length of the main growing season was shortening (Huho, 2011). The study revealed in the analyses presented above that March rainfall amounts had declined and become more unreliable. Thus the delayed onset of rains in March had forced some farmers to shift their planting dates to late March and others until mid-April in order to survive under an environment that is rapidly becoming arid. Shorter growing periods in the study area led to changes in crop varieties even to those with shorter maturity periods.

3.2.2 Poor yields due to ineffective rainfall

The MAM season seemed to have an overall increase in the rainfall, a condition suitable for rain-fed smallholder agriculture. However, increasing rainfall variability during the growing season led to droughts during the growing period. It was revealed by the divisional agricultural officers that early season droughts were common in Senetwo especially when planting was done in early March due to increase in "false rains". The officers 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 increasingly 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 onwards. The study attributed the occurrence of fewer mid-season droughts to the decreasing variability in April rainfall.

About 84% of the respondents were negative about obtaining good harvests due to late-season droughts, which had increased in the recent years. The respondents' assertion was confirmed by the analyzed May rainfall data which shows the number of rain days in May had been decreasing causing early cessation of the MAM seasonal rainfall. 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 of crops such as beans, if the 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.

Due to the semi arid nature of the area, frequent occurrences of droughts harden 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 gullies on the farmlands. According to IPCC (2007) climate change leads to greater soil erosion due to increased rainfall intensity.

3.2.3 Irregular planting dates

Increasing rainfall variability particularly in March made it difficult for farmers to plan for agricultural activities. Eighty four percent of the respondents stated that planting dates have increasingly become irregular with planting duration spanning from March to May (Figure 6).

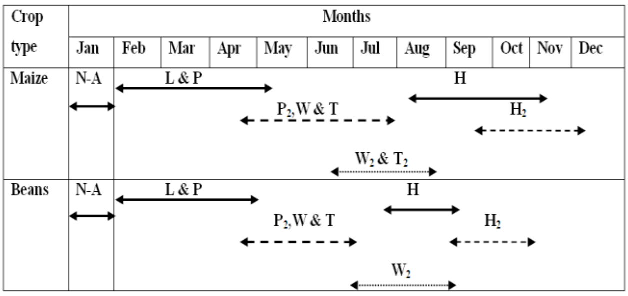

Figure 6: Irregular farming calendar in Chepareria Division: L= Land preparation for normal cropping cycle; P=Planting for first cropping cycle; P_2 =Planting for replanted cropping cycle; W = Weeding for normal cropping cycle; W2 = Weeding for replanted cropping cycle; T= Topdressing for normal cropping cycle; T_2= Topdressing for replanted cropping cycle; H = Harvesting for normal cropping cycle; H2 = Harvesting for replanted cropping cycle; and N-A = No Activity.

The study established that delays in planting affected all other farming practices such as weeding, topdressing and harvesting. The alteration of the farming calendar affected labour availability since the farmers depended on family labour especially 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.

4. Conclusion and Recommendations

The study thus revealed that although subsistence agricultural production in Senetwo location 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 factor. 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 agricultural production-the main livelihood option in the entire Chepareria division.

Knowledge of seasonal rainfall variability should be complimented with the understanding of socio-economic factors that impede smallholder farmers' adaptive capacity especially those living the harsh ASAL environment. There is need for livelihood enhancement initiatives that not only reflect people's preference, but also take cognizance of the irregular rainfall. Optimal farming strategies, scheduling of supplementary irrigation and field operations are measures to be considered if the Senetwo location is to overcome frequent crop failures. It is crucial for private and public actors to address the underlying causes of vulnerability in Senetwo such as infrastructure, literacy level and under-utilized water resources.

5. Acknowledgements

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