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# Assessing Agricultural Risks related to the Start, End and Length of the March – May Season in Nyando

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**Abstract:** ***Effective climate risk management requires access to climatic information that is timely, localized and relevant. The analysis of historical daily rainfall data can play a vital role in the generation of the much-needed climate information. 53 years of daily rainfall data for Kisumu were analysed to generate climate information needed by smallholder farmers in Nyando. The analysis involved understanding patterns of climate related events of some importance to farmers such as start of rains, end of season and length of season. This understanding was instrumental in helping the farmers plan, prepare and make informed decisions about the crops and varieties to plant and when to plant. This paper illustrates the approach used in the analysis and also presents and discusses the results of the analysis.***

**Keywords:** Climate change and variability, Climate risks, Climate information, Events

## 1 Introduction

In Nyando, like most of sub-Saharan Africa, agriculture plays a key role in the economic development of the area and sustenance of livelihoods. The sector is the main source of food, income and employment to a majority of the population who are smallholder farmers, [7]. Despite the area being agriculturally rich, food security continues to be a challenge with 81% of the households estimated to experience 1-2 hunger months in a year, [1]. The results of a recent baseline survey to establish challenges facing agricultural production in the area show that farmers' perceive climate change and variability as the main limiting factor to food security, [4]. Farming in the area is indeed rainfed and as such climate is a major driver of agricultural production.

To address the challenges of climate change and variability, the Kenya Meteorological Service (KMS), in their capacity as official providers of climate information services, are in the habit of supplying the seasonal climate forecast and advisories. These climate products are usually provided during the start of the each planting season to help farmers make informed decisions on when and what to plant based on the expected climatic conditions. However, according to farmers in Nyando, this information often arrives late into the season when the investment decisions have already been made. In addition the information, which is often for an entire region, is not localized enough to help with the specific climate challenges of the area. For effective management of climate risks, both timely and localized climate information is paramount, [2].

A tailored analysis of historical climate data can enhance smallholder farmers' capacity to respond to climate related risks to address food insecurity in Nyando. The analysis was performed for the Nyando farmers and it involved examining the probability of occurrence of climatic events that are of known importance to farmers in Nyando. The events of interest included but were not limited to start of rains, dry spells, end of the season and length of season. But before looking at these events, the analysis first involved checking whether long-term changes in rainfall have occurred in the recent past so that the risk analysis may be performed with the changes (or lack of them) in mind. This initial part of the analysis also helped to verify the perceptions of climate change in rainfall among farmers in Nyando, [6].

This paper illustrates the analysis which has now increasingly become easy to perform as tools and software to enable such an analysis continue to be developed. The analysis described by this paper used rainfall data only because the variability caused by rainfall was of immediate concern to the farmers in Nyando. But it can be extended to also include temperature records as well which are also available for Kisumu Meteorological Station. The rainfall records obtained for this analysis were on a daily scale as they are often of more value in the assessment of risks than monthly records. The results obtained from the analyses are also presented and interpreted in this paper.

## 2 Methodology

### 2.1 Study area and rain season of interest

Nyando is located in Western Kenya in the Lake Victoria Basin. The altitude is between 1140m and almost 3000m. The mean annual rainfall ranges from 800mm to 1600mm. The study was conducted within a 10km × 10km square within Nyando. The square had been selected as a learning site for the study by Climate Change, Agriculture and Food Security (CCAFS) research program. The program, which funded the study, is one of the many that exist under the umbrella of the Consultative Group on International Agricultural Research (CGIAR).

The rain season of interest for which the farmers wanted climate information was the March-May season. This is often referred to as the long rains season. This is the important season for food production for the farmers in Nyando.

### 2.2 Source of daily climate records

Daily rainfall and temperature records used in the study were obtained from Kisumu Meteorological Station. The station was selected because it was the nearest with long and consistent rainfall records which are required for effective assessment of climate-related risks for agricultural purposes. In addition, the station's records were found to be representative of the climatic conditions experienced in Nyando through an initial analysis of the records. The station is located at latitude -0.37 and longitude 35.27. The records exist for 53 years for the period between 1961 and 2013.

Access to the records was facilitated by the national meteorological office in Kisumu County. The office is mandated to liaise with like-minded organizations or initiatives in the county whose aim to improve access to climate information by farmers and other users. Due to restrictive data policy, the records were not allowed to leave the office but were accessed within the offices where the analysis was performed in collaboration with the meteorological staff. By working together, the meteorological staff were able to understand and acquire the skills required to perform the analysis.

### 2.3 Quality of the climate records

Even though the meteorological staff had checked the records for quality, a series of quality tests and checks were performed to validate the records again. Some of the validation checks performed include a check for zeros especially for the temperature records where zeros are impossible in the tropics, an outlier value check to identify and adjust impossible extreme values, variability check which involved identifying instances of unexpected differences in temperature values between successive days and lastly a missing value analysis to establish completeness of the records. A homogeneity test was also performed to check that the data were homogeneous in nature.

The results of the quality test were conclusive that the data were free of errors and therefore fit for analysis, [5]. Even though the process of quality checking and validation was long and tedious, we found the task to be useful as it helped to prepare the data for the analysis which became a straight-forward exercise that did not require going back and forth with data quality issues.

### 2.4 Analysing daily rainfall records for climate change

The rainfall records were first checked for evidence of climate change. This checking was mainly for two purposes. First, it was to confirm that the records can be used for the comparative risk analysis which can be misleading if the changes in records are not taken into account. Secondly the analysis was meant to establish whether the claims by farmers of climate change in rainfall were supported by evidence. In conducting this analysis, the IPCC [3] definition of climate change as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" was used.

The monthly summaries of rainfall were used. First the monthly totals were considered as they are a commonly used characteristic of rainfall. An ordinary linear regression model was fitted to these summaries against the year as the dependent variable. A linear trend was then fitted to check if there is any evidence of climate change.

The monthly number of rainy days were also considered. The initial task was to define a rainy day. A rainy day can take many definitions depending on the objectives of the analysis but for this study, the meteorological definition was adopted. A rainy day was therefore defined to be any day with rainfall amount greater than 0.85mm. Since the summaries are of a binomial nature, a generalized linear model was used to fit the monthly number of rainy days against year. A trend line was then fitted to check for evidence of climate change.

### 2.5 Start of rains with risk of dry spell

The analysis of start of rains was the first event to be assessed after confirming lack of evidence of climate change in the rainfall records. The analysis was undertaken to respond to the challenge of financial losses incurred by farmers as a result of replanting due to a dry spell following planting. The dry spell usually causes seedling death for crops that germinate when planted with rain. The farmers were interested in a planting date/period during the season where the risk of replanting is at lowest.

To respond to the challenge, three definitions of start of rains that represent three common characteristics of farmers were derived as follows:-

1. Bold farmer – Those who plant early in the season i.e. first occasion after 15 Feb with total rainfall 20mm over 2 days
2. Normal farmer – Those who plant during the start of the season i.e. first occasion after 1 Mar with total rainfall 20mm over 2 days
3. Cautious farmer – those who wait until later in the season when much rains have started i.e. first occasion after 15 Mar with total rainfall 20mm over 2 days

A dry spell condition was added to each of the above definitions to investigate the chances of replanting for the three types of farmers. A dry spell of 9 days in the next 30 days following replanting was considered. The dry spell condition was arrived at after consultation with the farmers.

For every year, a single value was derived for each definition of the start of rains. The climatic menu in the Instat+ software was used to process the events. Cases where replanting occurred were counted and probability calculated as a proportion of the period of the data set.

### 2.6 Dry spells

Although dry spells after planting were considered in the analysis described above, information about the risk of dry spells of varying lengths during the planting period is not provided. This was the motivation for conducting a risk analysis of dry spells. A dry spell can be damaging or not depending on how much rain has been received during planting. To cater for this variation, dry spell of varying lengths were considered. In this study, farmers together with the researchers agreed to investigate the occurrence of dry spells of more than 7 days, 10 days and 12 days. The results were presented using percentage of years for the occurrence of the different spell lengths.

### 2.7 End and length of the season

Farmers were also keen to know the length of the growing season in Nyando. A preliminary task was to determine the end of the season from which the start of the season can be subtracted to obtain the length. The end of a season was defined using the simplest FAO model namely when the water in the soils drops to less than 0.5mm. Instat+ software was used to obtain a summary value the end of season for each year of data. The length of the season was then computed and summarized for the different start of rain dates.

## 3 Results and Discussion

### 3.1 Analysing monthly summaries for trend

To investigate climate change in rainfall, a trend analysis was first performed for the monthly total rainfall. Fig 1 provides a visual representation of the results of analyses. According to the graph, there does not seem to be any evidence of climate change according to the monthly total rainfall. The trend analysis returned a large p-value (0.21) for the year. This result gives a first indication that the analysis of rainfall related events may be viable.

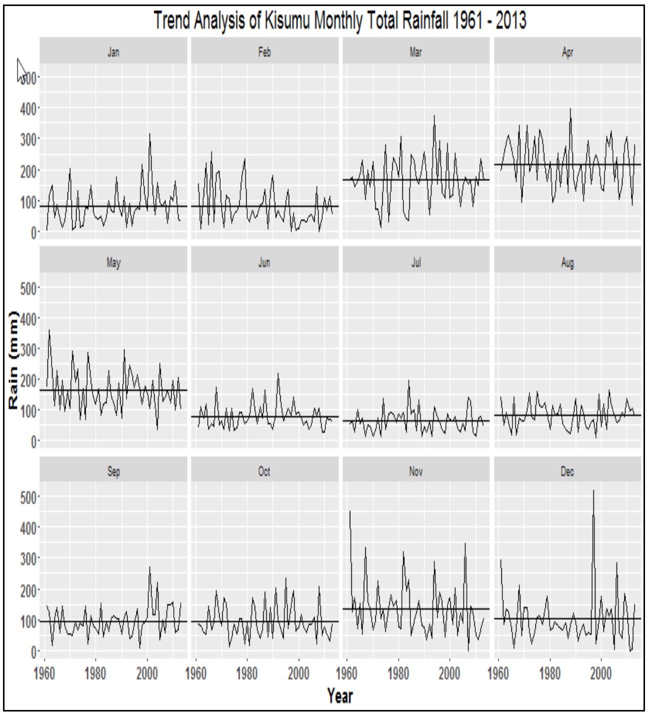


**Figure 1**: Analysing Kisumu Monthly Total Rainfall for Trend

Since the monthly totals are obtained from the rainfall amounts received on rainy days, the investigation of climate change was extended to involve the monthly number of rainy days. Fig 2 shows the results of the analyses for the monthly number of rainy days in Kisumu. A visual examination of the results also reveals that there is no evidence of climate change in rainfall according to the number of rainy days.

In summary there is lack of evidence to support the claim by farmers that there is climate change in rainfall. This is from the total rainfall and number of rainy days. The lack of evidence could either mean that there is no climate change in the rainfall data or that there is change but it is masked by the large inter-annual variability that makes it difficult to detect it. This observation leads to the conclusion that farmers should not be changing their farming strategies in the narrative of a changing climate.

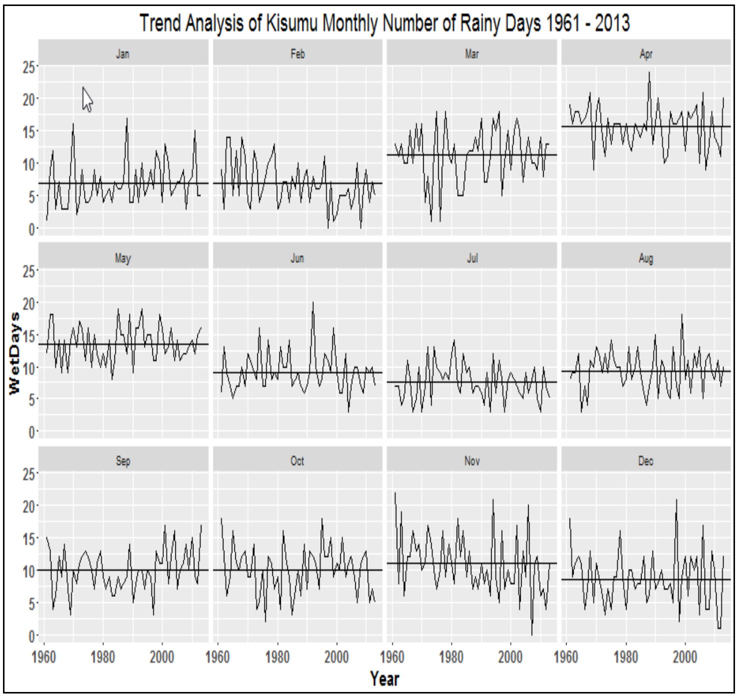


**Figure 2**: Analysing Kisumu Number of Rainy Days by Month for Trend

### 3.2 Start of rains with risk of dry spell

The risk of replanting was investigated using three different definitions of starts of rain. We first considered a 'bold' farmer who planted early in the season namely after 15 February. The results are shown by Fig 3. The chance of replanting is 0.2 or in other words, 1 year in 5. According to Fig 4, the risk of replanting is reduced by more than half if planting occurs after 1st March. The chance is approximately 0.07 which is 1 year in 10. For those who plant very late, the risk of replanting is reduced further to 1 year in 20. Even though planting later in the season reduces the chance of replanting, it shortens the length of the season. This means that farmers who are 'cautious' cannot plant long-maturing crops because of the reduced length of season. The implications are illustrated further in detail in the analysis of end of seasons in this paper.

A trend analysis was also performed on the planting dates for each type of farmer. The results did not provide evidence of climate change in the start of rains for the 53 year period. The same conclusion is supported visually from the graph where there is no tendency for either an upward or downward monotonic change in pattern. This implies that the dates for the start of rains have not been changing. However they are variable from year to year. Farmers have therefore to cope with the variations.

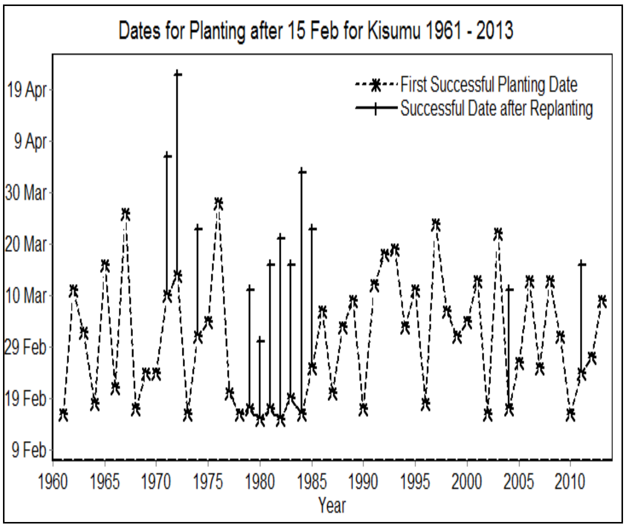


**Figure 3:** Start of Rains after 15 Feb

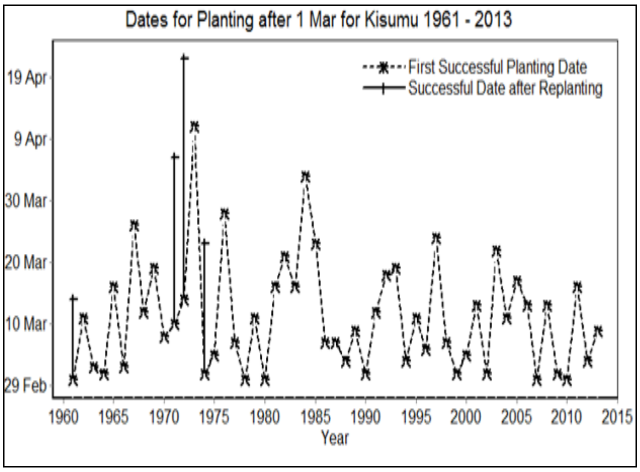


**Figure 4:** Start of Rains after 1 Mar

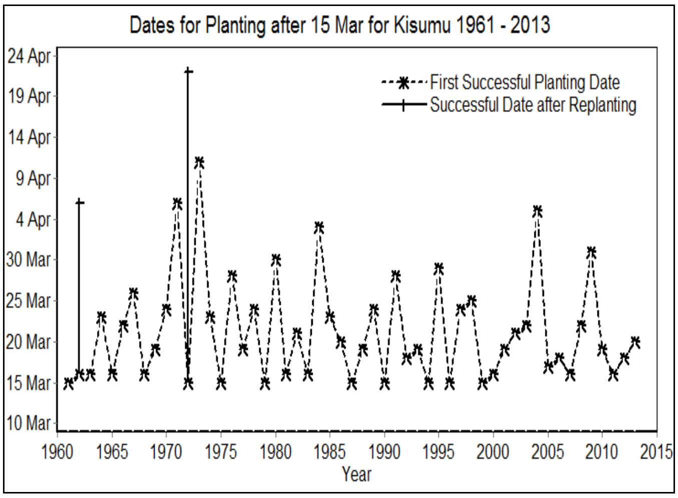


**Figure 5:** Start of Rains after 15 Mar

### 3.3 Dry spells

To understand the occurrence of dry spells, Fig 6 summarizes the risk of dry spells of 7, 10 and 12 days during a 30 day period following planting dates from 15 February to 30 March conditional on the initial day being rainy. For crops planted early in the season (15 February) the risk of a dry spell of more than 7 days is highest at 78% or 4 years in 5. The risk reduces gradually for crops planted after 15 February to a low of 20% for those planted on 30 March. The risks of 10 days and 12 days are lower than those of 7-day dry spells but the two converge for crops planted after 18 March. While delaying planting could reduce the risk of dry spell, it must be done with the growing period of the crop in mind as the decision could shorten the season.

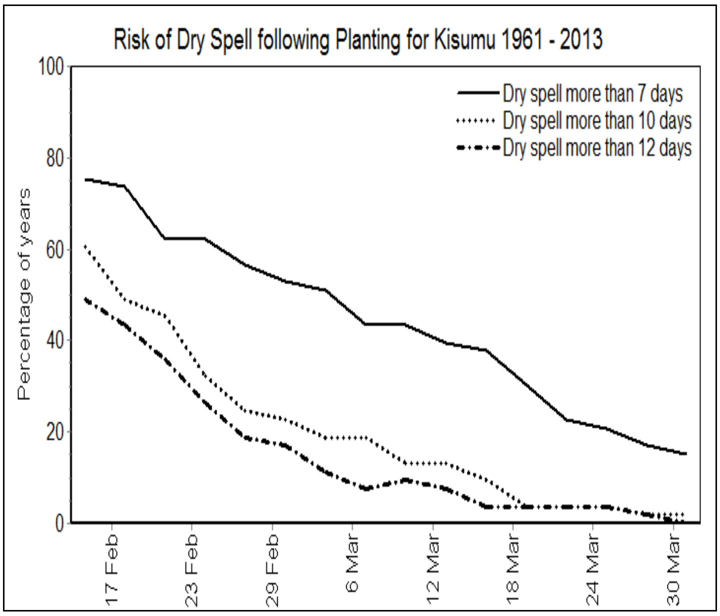


**Figure 6**: Risk of Dry Spells following Planting

### 3.4 End of Season

To understand the variability in the length of a growing season in Nyando, the end of the season for Kisumu was first analysed. A preliminary task was to determine the end of rains which was achieved by examining the rainfall pattern in Kisumu on a daily basis. It was established that rains subside towards the end of May. This date was used to define and estimate the end of a season whose results are presented by Figure 8.

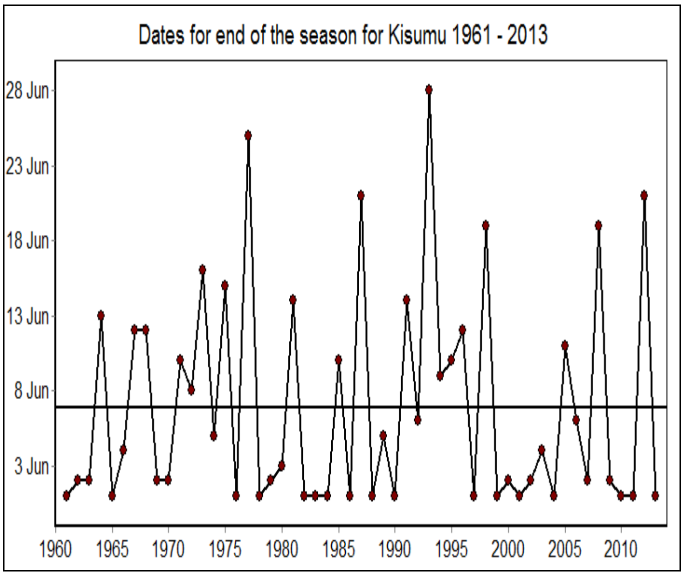


**Figure 7:** Dates for end of season

The dates for the end of the season ranged from 1st June to the 28th June for the period of 53 years. The mean date for the end of the season was 6th June.

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### 3.5 Length of season

The length of season was analysed for the three different starts of the rains definitions. Fig 8 – 10 summarize the results using a graph. For the bold farmer, the length of the season is slightly longer than for the farmers who plant in March. The 90 day season implies that farmers can comfortably plant crops that take 90 days to mature. Shorter-duration crops are recommended for cautious farmers who plant late in the season as the length of the season shorten to about 78 days in total.

Visually and from a simple regression analysis, there was no change observed in the lengths of the season.

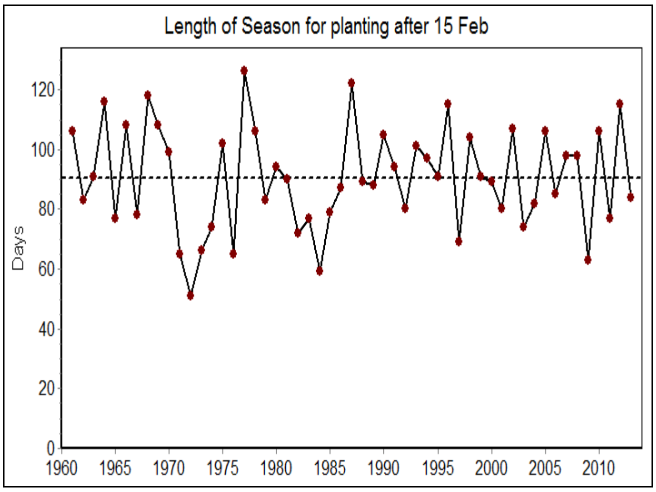


**Figure 8**: Length of season for planting after 15 Feb

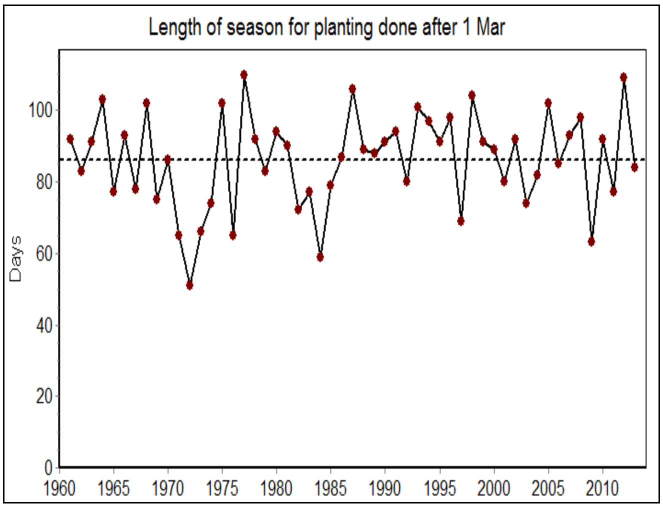


**Figure 9**: Length of season for planting after 1 Mar

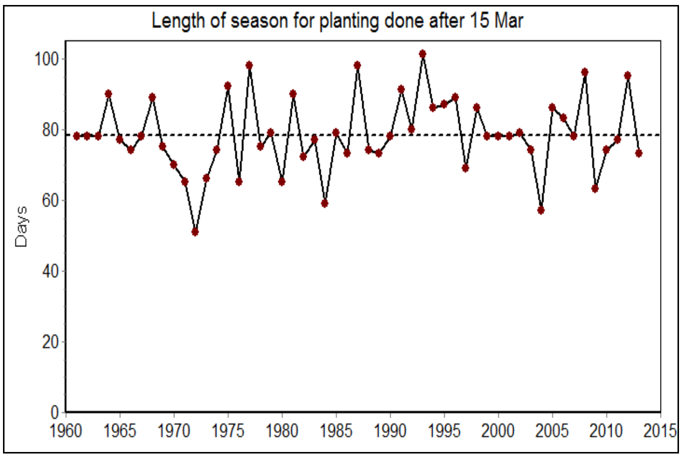


**Figure 10**: Length of season for planting after 15 Mar

## 4 Conclusion

This study was set out to understand the rainfall characteristics of agricultural importance to smallholder farmers in Nyando. Rainfall records from the Kisumu Meteorological Station were used to generate the needed climate information for farm decision-making processes. The Kisumu daily rainfall records were found to be representative of the climatic conditions in Nyando and can therefore be used in future climate studies within the area.

The start of rains was analysed for the period between mid-February to the mid-March when the season is just taking off. The risk of replanting was found to be at the lowest in March than in February. However, the study found that waiting longer than necessary shortens the length of the season which was observed to end early June. Dry spell of 7 days were found to be more prominent during the early planting period of the season but reduced gradually as the season progressed.

This analysis was performed easily using a basic statistics package called Instat+ software. The software has a climate menu with functionality designed to perform this analysis. It is the recommendation of this study that Meteorological staff, extension workers and other stakeholders are equipped with the skills they need to perform this analysis for the consumption of smallholder farmers.

## 5 Acknowledgement

We acknowledge the support of CCAFS East Africa program who are responsible for funding this study for a period of 2 years. We also appreciate the input of farmers without which this study would not have been successful. Last but not least, we are grateful to the Kisumu County Meteorological Office who provided access to the daily climate records for the Kisumu Meteorological Station which were used to generate the results described in this study.

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## Author Profile

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