

## Establishing the Rainfall Trend over Bungoma Region in Kenya, During the Short and Long Rain Seasons

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### Authors' contributions

*This work was carried out in collaboration between both authors. Author DMM designed the study, performed the statistical analysis, wrote the draft of the manuscript. Author SWW managed the analysis of the study and literature searches. Both authors read and approved the final manuscript.*

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## Abstract

This paper is aimed at presenting the temporal and spatial variability of rainfall over Bungoma region between 2000 and 2015. Rainfall data was obtained for 5 stations in the region. The data was subjected to analyses by use of Microsoft Excel and SPSS. The results from analysis of the data showed that the March, April, and May (MAM) and October, November, and December (OND) rainfall totals showed a general increasing trend in all the stations. The MAM season was found to have the most reliable rainfall in all stations while the OND season was reliable in some of the stations in the study region. Kanduyi region is seen to receive the highest amount of rainfall all through the years, and Tongaren the Least amount of Rainfall. The significance of these findings is that it could be used by various policymakers and development partners for planning purposes.

*Keywords: Rainfall trend; OND; MAM and JA season; mean monthly rainfall; forecasting.*

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## 1 Introduction

Bungoma region receives a lot of rainfall almost throughout the year. This makes the region main economic activity to be rain-fed agriculture with very little irrigation involved. This dependency on rainfall makes it very important for studies to be carried out on the weather of this region.

Previous studies of Bungoma region indicate that it has three rainfall seasons: the MAM or “long rains” season, the July and August (JA) or “middle rains” season and the OND or “short rains” season. This helps the region to become an agriculture supporting zone. Since most agricultural activities happen during the MAM and OND seasons, our study has focused on them. This region exhibits both spatial and temporal variability. Rainfall patterns over Bungoma specifically, are influenced by the Lake Victoria and the highland regions.

Many researchers like Morth and Johnson [1], Asnani [2], Okoola [3] and many others, have a lot of research on rainfall patterns over Bungoma and at large, the western region. They indicated that this region receives high amounts of rainfall and excess or disastrous rainfall is not common [4].

Since many East African economy depends on rain-dependent agriculture that is according to Ongoma, [5], Ngetich et al. [6] and funk et al. [7], making this research very significant since this region contributes a lot in the economy of East Africa. According to studies performed by Oettli and Camberlin [8] and Nyakwada [9], rainfall in the Bungoma highly varies in temporal and spatial scales. This led to large water bodies like Lake Victoria. At large, the western region lies in the tropics and henceforth it is probable for it to experiences a bimodal rainfall pattern consisting of the long and short rains.

### 1.1 Statement of the Problem

Rainfall is a very important factor in the Bungoma region of Kenya since its main economic activity is agricultural independent. Failure of not knowing the trend in the region has caused continuous deterioration in production. Henceforth the study on rainfall trend in Bungoma is very vital in the region.

### 1.2 Significance of the Study

Analysis of the rainfall trend over Bungoma region during the MAM and OND rain seasons is very important mostly for agricultural purposes. The analysis involved rainfall data for a period of 16 years. This data is very important especially for forecast purposes. This study has provided important information about the patterns of rainfall during the short and long rains over Bungoma region. The information provided can be very useful for planning purposes mostly in transportation, agricultural sector and other sectors affected by rainfall. This study is of the utmost importance to farmers to inform them whether the two seasons are really reliable for rain-dependent agriculture and when to do irrigation.

## 2 Methodology

### 2.1 Data

Monthly rainfall totals from five representative stations in Bungoma region were used in the analysis. The monthly rainfall data was acquired from the Bungoma Meteorological Office and it ranged from 2000-2015. Table 2.0 below shows the names of the stations used.

## 2.2 Estimation of missing rainfall data

Missing data is usually expected in meteorological data and these gaps can be estimated using different methods including, correlation, regression and arithmetic mean methods. The dataset did not contain any missing information [10].

**Table 2.0. The stations used**

Station number	Station name
1	KANDUYI
2	KIMILILI
3	WEBUYE EAST
4	MT. ELGON
5	TONGAREN

## 2.3 Homogeneity test

To test for homogeneity of the rainfall data for the stations, single mass curve method was used. This involves plotting the cumulative totals against the years.

## 2.4 Method used

Time series analysis was carried out in the analysis of the rainfall data. The trend analysis technique was used.

### 2.4.1 Analysis of time series

If quantitative data are arranged as they occur, the resulting series is called referred to as a time series. The quantitative values are normally recorded over an equal time interval daily, weekly, monthly, quarterly, half-yearly, yearly, or any other time measure. Time series are influenced by various types of forces. Some are continuously effective other make themselves felt at recurring time intervals, and still others are non-recurring or random in nature. Henceforth, the first task is to break down the data and study each of the influences in isolation. we call this decomposition of time series. It helps us to understand well the nature of the forces at work. We can finally analyse the combined interactions. Such studies are known as time-series analysis [11].

### 2.4.2 Arima

The modeling and forecasting procedures discussed in Identifying Patterns in Time Series Data involved knowledge about the mathematical model of the process. However, in real-life research and practice, patterns of the data are unclear, individual observations involve considerable error, and we still need not only to uncover the hidden patterns in the data but also generate forecasts. The ARIMA methodology developed by Box and Jenkins [12] allows us to do just that; However, because of its power and flexibility, ARIMA is a complex technique; it is not easy to use, it requires a great deal of experience, and although it often produces satisfactory results, those results depend on the researcher's level of expertise [13,14].

### 2.4.3 Autoregressive process

Most time series consist of elements that are serially dependent in the sense that you can estimate a coefficient or a set of coefficients that describe consecutive elements of the series from specific, time-lagged (previous) elements. This can be summarised in the equation:

$$X_t = \varphi + \phi_1 * X_{(t-1)} + \phi_2 * X_{(t-2)} + \phi_3 * X_{(t-1)} + \dots + \varepsilon$$

Where:

$\varphi$  Is a constant (intercept),  $\phi_1, \phi_2, \phi_3$  Are the autoregressive model parameters,  $X_{(t-1)}, X_{t-2}, X_{(t-3)}$  are the corresponding autoregressive processes and  $\varepsilon$  is the corresponding discrete random process.

Put into words, each observation is made up of a random error component (random shock,) and a linear combination of prior observations [11].

### 2.5 Trend analysis

Graphical and statistical method was used to determine the trends of rainfall during the two seasons, MAM and OND.

### 2.6 Graphical method

This method involved plotting the rainfall data for a given season against time on a graph then fitting the trend line on the graph. If the slope of the trend line was positive then there was an increasing rainfall trend but if the slope was negative then there was a decreasing rainfall trend.

## 3 Results and Discussion

Here, we discuss the results obtained during analysis and their significance in our study. These discussions will help us in formulating our conclusion and recommendations. The results are as discussed below.

### 3.1 Homogeneity

The results of homogeneity tests of the stations using the single mass curve method are as shown below;

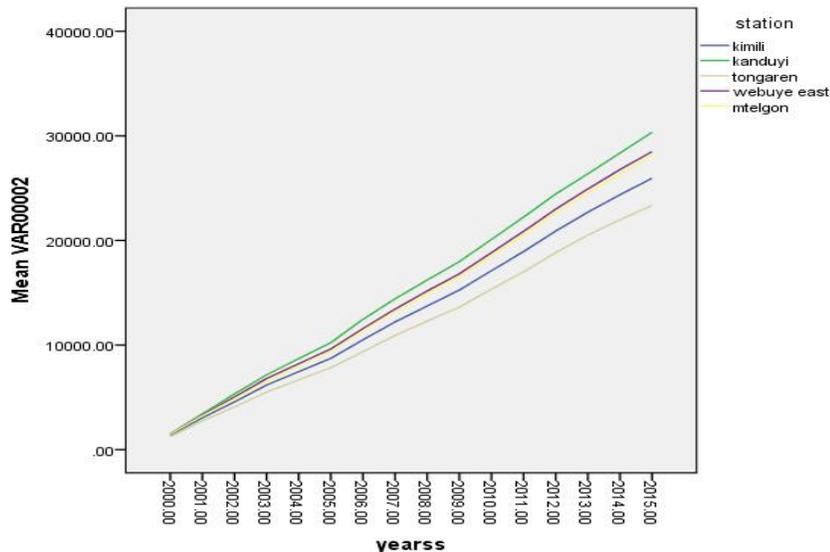


Fig. 3.0. Homogeneity tests for the stations

Fig. 3.0 shows the outcome of the single curve method in testing for homogeneity. It indicates that all the lines depicted straight lines. This idea of straight lines in the single mass curve method indicates that data from all the stations were found to be homogeneous. This is an indication that all the data used was relevant.

### 3.2 Mean monthly rainfall analysis

The figures below show the plot of the monthly mean for a period of 16 years against the months. This figure is very significant in displaying the months producing the highest and least amount of rainfall over the time.

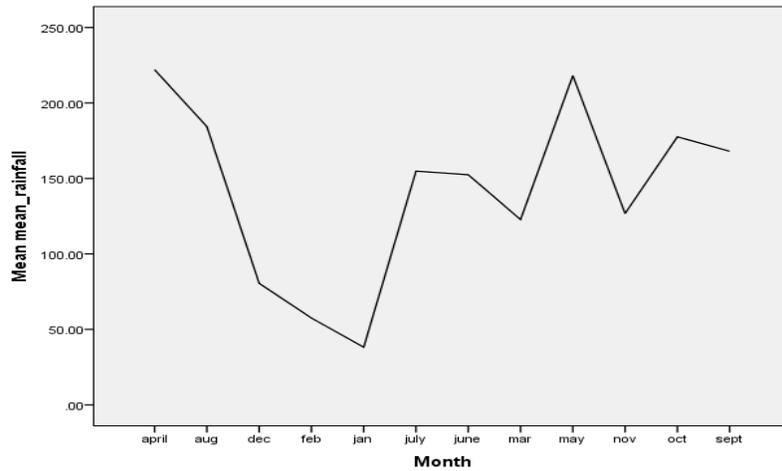


Fig. 3.1. Line graph for mean monthly rainfall

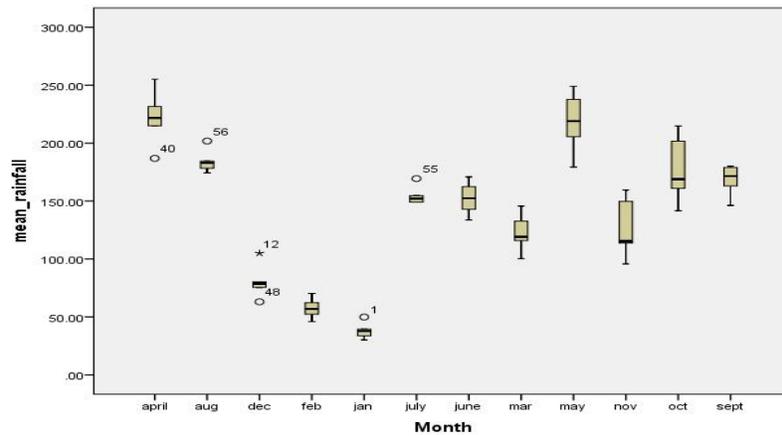


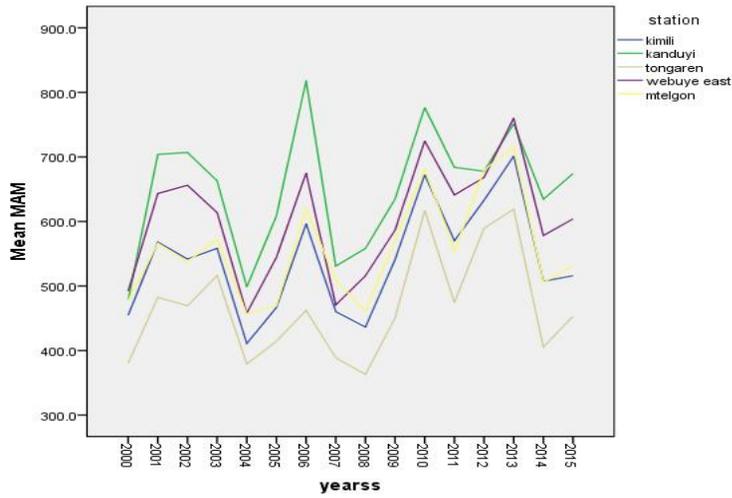
Fig. 3.2. Box plot for monthly mean

Figs. 3.1 and 3.2 shows the plot of monthly mean, averaged over a period of 16 years against every month. From the figures, it is clear that April received the highest amount of rainfall in the study period, followed by May and August. January, February, and December are seen to have dry spells all through. From this, It is clear that most MAM months appear in the list of those with the highest rainfall. This is a clear indication

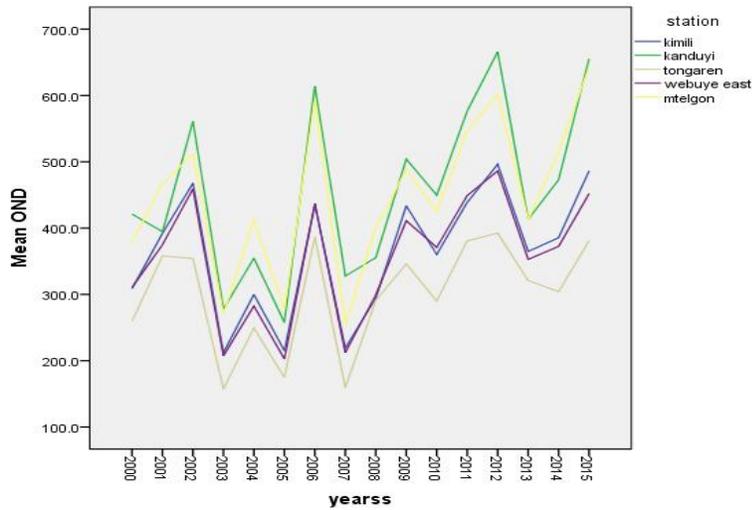
that the season is greatly reliable for Agriculture. Also, keen observation shows that the months of OND have little amounts of rainfall compared to MAM.

**Table 3.3. MAM and OND mean totals for all station in Bungoma region**

Station name	Average total rainfall	
	MAM	OND
KANDUYI	649.975	456.375
KIMILILI	539.2067	363.8933
WEBUYE EAST	602.0125	355.0125
MT. ELGON	556.6938	499.9438
TONGAREN	466.5125	300.35



**Fig. 3.4. Mean amounts for MAM rainfall seasons for all stations**



**Fig. 3.5. Mean amounts for OND rainfall seasons for all the stations**

Table 3.3, Figs. 3.4 and 3.5 shows the average total MAM and OND rainfall recorded at the various stations in the study region. From the table and the figures above it is noted that Kanduyi station recorded the highest amounts of rainfall during the MAM and OND seasons. Webuye East is also seen to have moderately high amounts of rainfall. This region can also do very well in the agricultural sector. Tongaren recorded the lowest amount of rainfall for both MAM and OND seasons. The rainfall values for Tongaren indicate that the area is likely to be found within a different catchment area from the rest of the areas in the study region. The low amounts in Tongaren are a clear indication that it might be found in a different catchment area.

All stations are capable of supporting rain dependent maize farming during both the MAM and OND seasons since maize requires at least 350mm for its growth and maturity, except for Tongaren in the OND season. During the MAM season, the County Government should keep people alert about the large amounts of rainfall to allow good planning and preparation of gardens and also the transportation sector.

### 3.4 Trend analysis

The trend analysis for both MAM and OND seasons have been performed in the study and the results displayed below.

#### 3.4.1 Trends for the MAM rainfall totals

The figures below show the results on trend line analyses of the five stations in the study region during the MAM season.

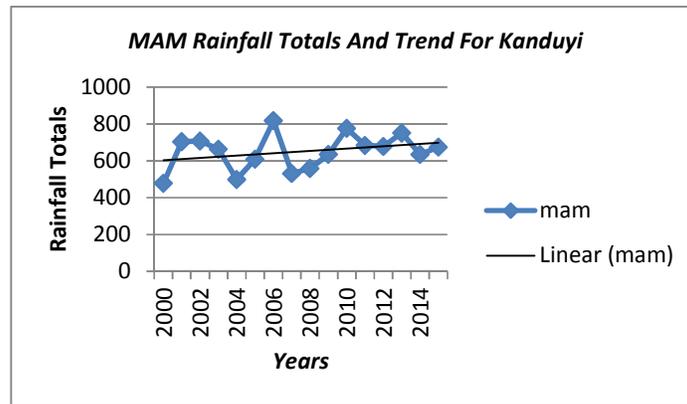


Fig. 3.6. MAM rainfall totals and its associated trends line for all Kanduyi

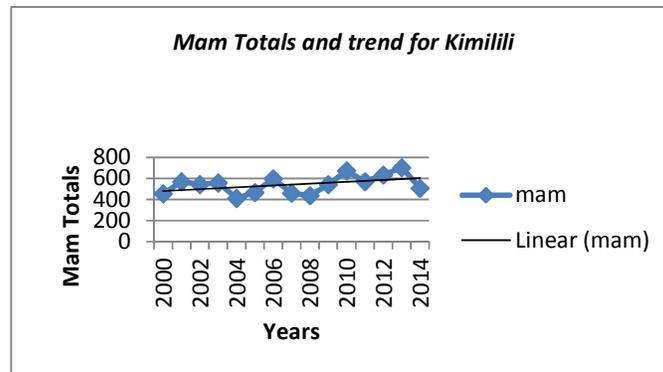


Fig. 3.7. MAM rainfall totals and its associated trends line for all Kimilili

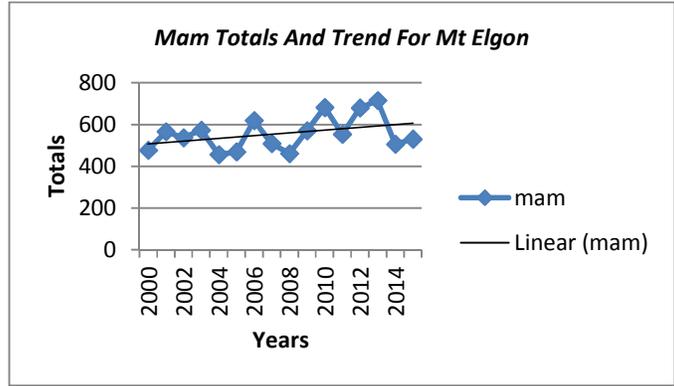


Fig. 3.8. MAM rainfall totals and its associated trends line for all Mt Elgon

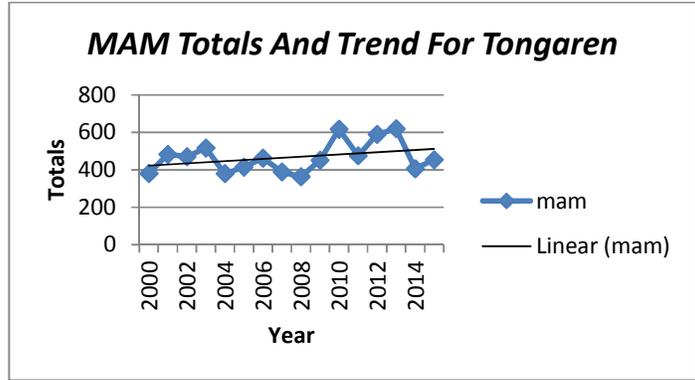


Fig. 3.9. MAM rainfall totals and its associated trends line for all Tongaren

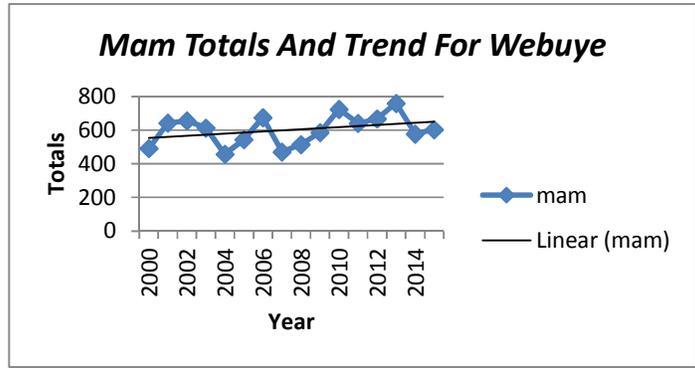


Fig. 3.10. MAM rainfall totals and its associated trends line for all Webuye

The figures above displays the MAM rainfall totals of all the stations. According to Fig. 3.5, all station appeared to have an increasing trend in total rainfall during the MAM season. Though all the regions shows a general increasing trend, Kanduyi’s trend is seen to increase in a higher gradient than the others. This implies that the region will still be having lot of rain in the future days. Also from the figure of Tongaren, it

shows that although it receives little amounts of rainfall, the amount have been and will be increasing in the future.

### 3.4.2 Trends for the OND rainfall totals

The figures below displays the results of trend line analyses of the five stations region during the MAM season.

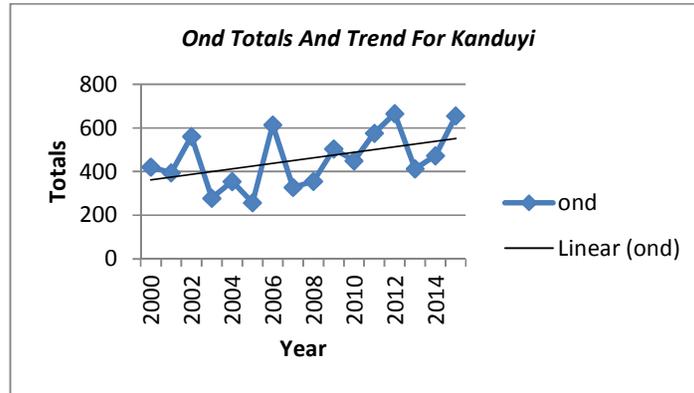


Fig. 4.0. Kanduyi rainfall totals and its associated trends line for all Kanduyi

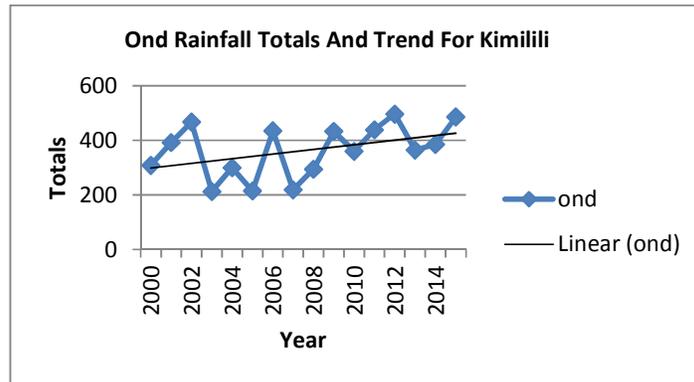


Fig. 4.1. OND rainfall totals and its associated trends line for all Kimilili

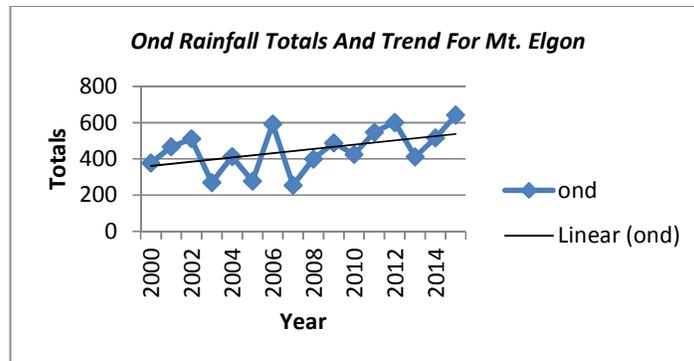


Fig. 4.2. OND rainfall totals and its associated trends line for all Mt Elgon

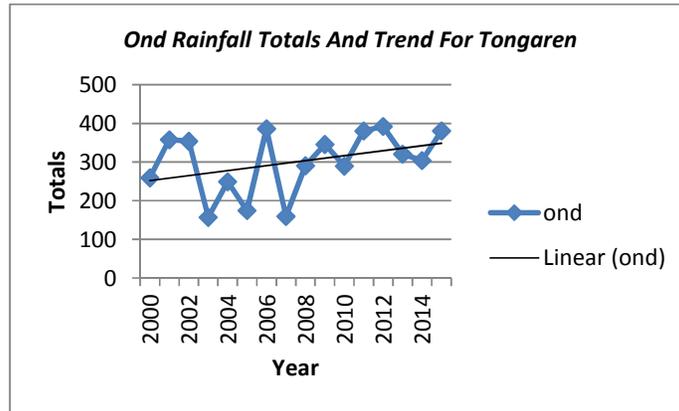


Fig. 4.3. OND rainfall totals and its associated trends line for all Tongaren

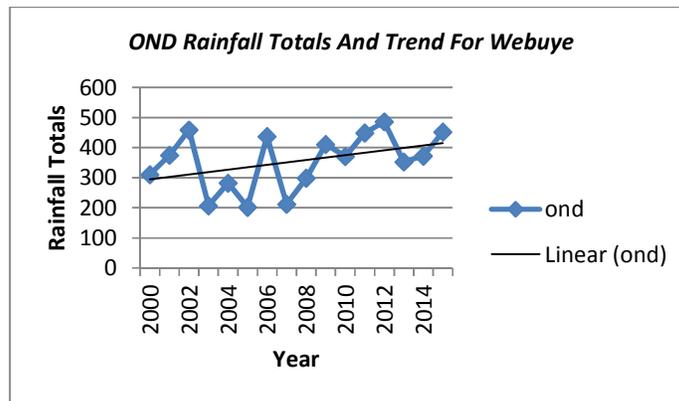


Fig. 4.4. OND rainfall totals and its associated trends line for all Webuye

Figures above show the trend for all the stations in the OND season during the study period for all stations. It was noted from the figures that all stations depicted a general increasing trend in rainfall totals during the OND season. It is also clear that Kanduyi followed by Webuye East depicts a higher gradient of the increasing trend. It is also clear from the observations that Tongaren region shows a significant increase of rainfall amounts from the past. This shows that in the future, if the right measures are put in place, then the region will be receiving large amounts of rain. This is significant to rain-fed agricultural activities since it implies that the OND season is gradually becoming suitable for rain dependent agricultural activities.

## 4 Conclusions

All stations clearly indicate a generally increasing trend in totals during the two seasons implying that the seasons are suitable for rain-dependent agriculture in the future. Kanduyi region is seen to receive the highest amount of rainfall, and hence the area is the most reliable for rain-fed agriculture. The MAM season was found to have the most reliable rainfall in all stations while the OND season was reliable in some of the stations in the study region. Tongaren region is said to receive the least amounts of rainfall. It is clear from all the analysis trend due to the positive trend throughout, the amounts will be increasing in the future, Making Bungoma region to be dependable on rain-fed agricultural activities.

## 5 Recommendations

The following recommendations were made from the study:

1. More studies should be carried Studies should be done in Tongaren region to investigate the causes of little rainfall received as well as developing adaptation strategies to the farmers.
2. Since the focus of this study was on the MAM and OND seasons alone, studies should be conducted on the other seasons to see whether they can be utilised for rain-fed agriculture and if not whether supplementing them with irrigation can make them suitable for agricultural activities.

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## Competing Interests

Authors have declared that no competing interests exist.

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