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Research Application Summary

Temperature variation and its impacts on maize and cassava production in Mayukwayukwa refugee settlement

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Abstract

Understanding temperature variation and trend is imperative especially among the majority agriculture experts in the Sub-Saharan Africa who wish to understand the effects of climate change. Many studies on climatic variables including temperature and rainfall have been undertaken at national level in recent years in Zambia. However little has been done and known at local level as to whether or not the observed variation and trend in temperature in recent years is statistically significant. The study investigated the variation of temperature in Kaoma District in Zambia. It examined the time variation and trend in temperature observed impacts on maize and cassava production in Mayukwayukwa Refugee Settlement. In order to understand the temperature variation throughout the period 1974 to 2014, the analysis focussed on the trend of variation for temperature as the only parameter. Three climatic scenarios extending from 1974 to 2004, 1984 to 2014 and the overall period of 1974 to 2014 were developed and analyzed using regression equations computed by geo informatic tools. The range of variation of temperature computed was 4.4 ^{0}C and the annual average temperature obtained was 29 ^{0}C. The results obtained indicated that temperature in Kaoma has been on the rise by 1.9 ^{0}C which can be translated into 0.4 ^{0}C per decade. This is consistent with the reports by Sichingabula (1998) and Makano (2011) who indicated that there had been a rise in temperature in the country by 0.3 ^{0}C per decade and that this has reduced production on rain-fed crops.

Keywords: Climate change, temperature variation, trend analysis

Résumé

Comprendre la variation et la tendance de la température est impératif, surtout pour la majorité des experts en agriculture de l'Afrique subsaharienne qui souhaitent comprendre les effets du changement climatique. De nombreuses études sur les variables climatiques, y compris la température et les précipitations, ont été entreprises au niveau national ces dernières années en Zambie. Cependant, peu a été fait au niveau local pour savoir si les effets de la variation et la tendance de la température observées ces dernières années sur la production de maïs et de manioc sont statistiquement significatives ou non. L'étude a porté sur la variation de la température dans le district de Kaoma en Zambie. Elle a examiné la variation temporelle et la tendance des impacts de la température observés sur la production de maïs et de manioc dans le camp de réfugiés de

Mayukwayukwa. Afin de comprendre la variation de la température au cours de la période 1974 à 2014, l'analyse s'est concentrée sur la tendance de la variation de la température comme seul paramètre. Trois scénarios climatiques s'étendant de 1974 à 2004, 1984 à 2014 et la période globale de 1974 à 2014 ont été développés et analysés en utilisant des équations de régression calculées par des outils géo-informatiques. La plage de variation de la température calculée était de 4,4 0C et la température moyenne annuelle obtenue était de 29°C. Les résultats obtenus indiquent que la température à Kaoma a augmenté de 1,9°C, ce qui peut être traduit en 0,4°C par décennie. Ceci est en accord avec les rapports de Sichingabula (1998) et Makano (2011) qui ont indiqué qu'il y avait eu une augmentation de la température dans le pays de 0,3°C par décennie et que cela a réduit la production sur les cultures pluviales.

Mots clés : Changement climatique, variation de la température, analyse des tendances

Introduction

The issue of climate variability and change and its impacts on society, with changes in rainfall and temperature already evident in many parts of the world, is one of growing concern to both the global and local communities. This holds true also for Zambia where various communities are already experiencing climate induced hazards such as extreme temperature, drought, dry spells and seasonal flash floods (Makano, 2011). Climate change and variability will impact food, fiber and forests around the world (Cody and Smith, 1997). The DAPD (1999) estimated that by 2100 Sub-Saharan Africa (SSA) will experience losses of 0.4 to 1.3% of forest cover and decrease in suitable rain-fed land and production potential for cereals by 2080.

With the poor majority in SSA still depending on rain-fed agriculture for their livelihood, one cannot talk of food security without addressing the issue of food availability, and one cannot speak of food availability, which is directly linked to crop production and distribution, without taking into account climate change and variability (Kahya and Kalaci, 2004; IFPRI, 2006). The most significant and direct impacts of climate change over the next few decades will be on food systems. Increasing temperatures and declining precipitation in semiarid regions are likely to reduce yields for maize, wheat, rice, and other primary crops in the next two decades (Onoz and Bayazit, 2008).

In Zambia, the natural ecosystem is under threat by climate change and variability. The mean annual temperature has increased by 1.3 °C since 1960, with all of the country's three agro-ecological regions experiencing warmer winters and hotter summers (Pennycuick and Kahya, 2006) while annual rainfall has decreased by 1.9 mm per month (or 2.3% per decade) since 1960, particularly in the months of December, January and February (Perera *et al.,* 1976). These changes have led to more frequent and intense droughts, floods, extreme heat, and erratic rainfall, which threaten, among other things, food security in Zambia where agriculture is largely rain-dependent. The majority of the population in rural areas (about 60%), in particular women and vulnerable people, depend on rain-fed agriculture for their livelihood. Of particular interest among the vulnerable people are the refugees who live in specific areas designated by the Government of the Republic of Zambia as agriculture settlements.

Considering the importance of rain-fed agriculture for the economy and food requirements of

the vulnerable people, with particular focus on refugees, the main aim of this study is to provide reliable estimates of maize and cassava production under varied climate change provisions and circumstances. Thus, the first objective was to analyze the recent and future trend of annual and average temperature. The second objective was to investigate potential impacts of observed recent and predicted future temperature variation on maize and cassava production in Mayukwayukwa Refugee Settlement.

Material and Method

Required data on agriculture and temperature were obtained from the Ministry of Agriculture and the Zambia Meteorological Department, respectively. The agriculture data consist of annual maize and cassava production (metric tons per year). The average monthly temperature data covered the period from 1974 to 2014.

Exploratory analysis. Descriptive analysis was the first step undertaken to analyze climatic data in order to determine the temperature variations in Kaoma District. Trend lines versus time and scatter plots were developed for presentation of graphs. To better understand the temperature variability and change throughout the period 1974 to 2014, the analysis was devoted to generate the trend of variation of temperature for three climatic scenarios extending from 1974 to 2004, 1984 to 2014 and the overall period of 1974 to 2014. Trends of annual temperatures in five-year moving average fashion were computed for each year during 1974 to 2014, by plotting data in SPSS. These five-year moving averages of annual climatic data have been used to obtain the regression equations.

Impacts on maize and cassava production. The study investigated the possible linkage between the climate variability and change and trends of maize and cassava production so that the impact on crop production could be assessed. For this part of analysis, the production data of two types of crops, maize and cassava, were used to identify the trend of production of these crops in response to the annual temperature for the period of 2006 to 2014. Then an attempt was made to investigate possible correlation between the trend of local climate change and trend of change in the maize and cassava production, so as to establish possible impact of the local climate change on food production during the specified period.

Results

Scenario 1: Mean annual temperature 1974 – 2004. As shown in Figure 1, the trend shows an increase in the five-year moving average of annual temperature but this trend was statistically insignificant. From 1974 to 2004, temperature increased by 1.7 ^{0}C. Figure 2, shows the variation from the 30year mean. From the early 1982s to late 1984, a sharp increase in temperature was recorded. This was above the normal (29 ^{0}C) for the entire scenario. The temperature increased by about 3 ^{0}C in a space of four years.

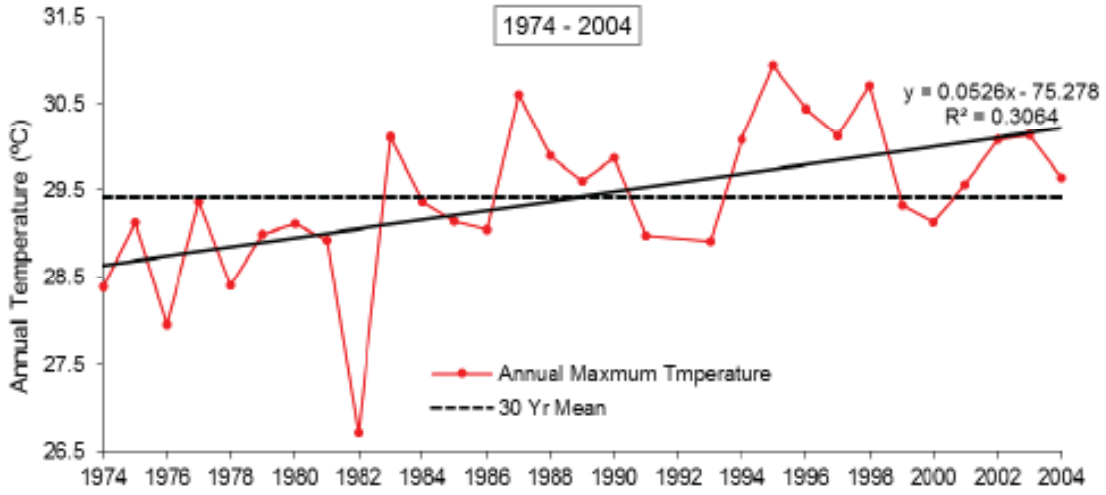

Figure 1. Five year moving average of Annual Temperatures (1974 – 2004)
Source: Zambia Meteorological Department

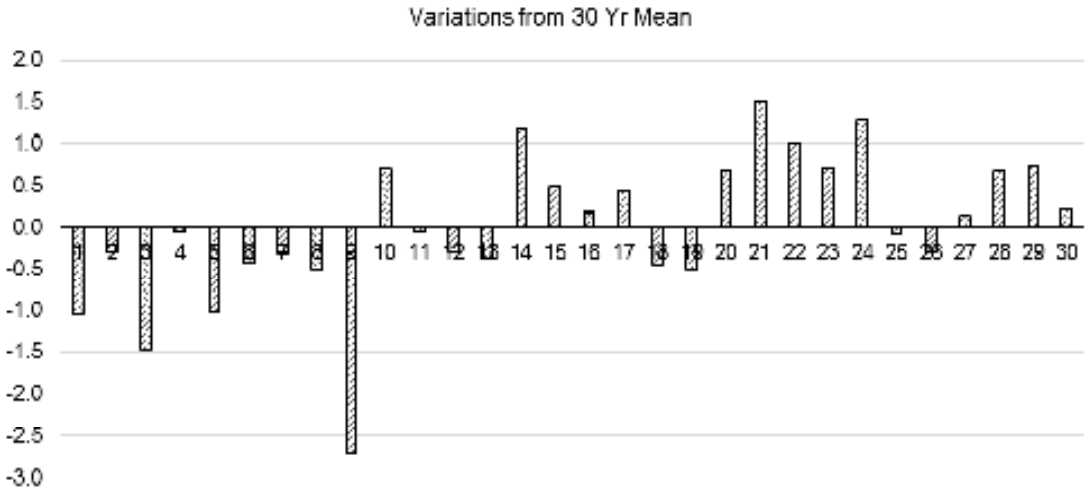

Figure 2. Variation from the 30 year mean for the years 1974-2004
Source: Zambia Meteorological Department

Scenario 2: Annual temperature 1984 – 2014. Figure 3 shows the trend in the five-year moving average of annual temperature which shows an increase in temperature. From 1984 to 2014, temperature increased by 0.2^0C. Figure 4 shows the variation computed from the 30yearr mean. The highest temperature was recorded between 2010 and 2014 which was over 31 ^{0}C. The trend was statistically insignificant.

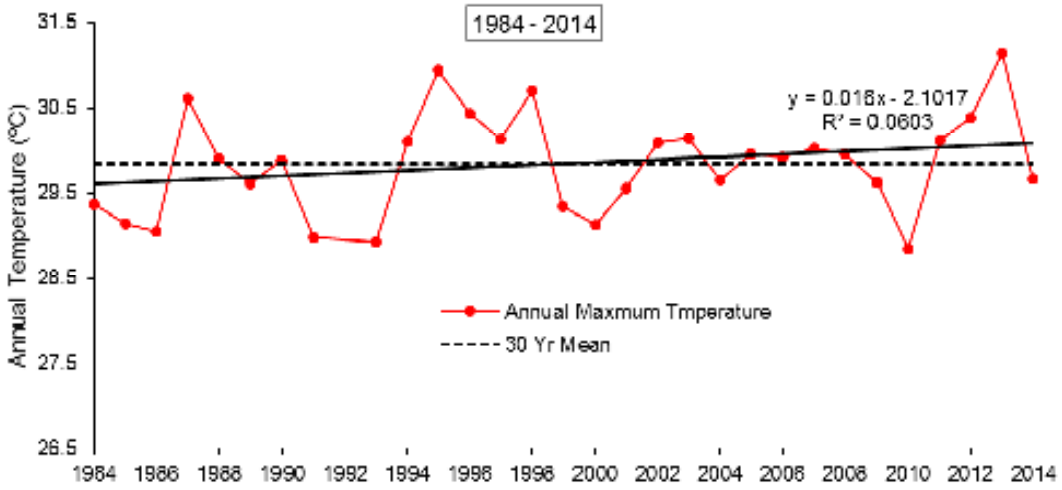

Figure 3. Five year moving average of Annual Temperature (1984 – 2014)
Source: Zambia Meteorological Department

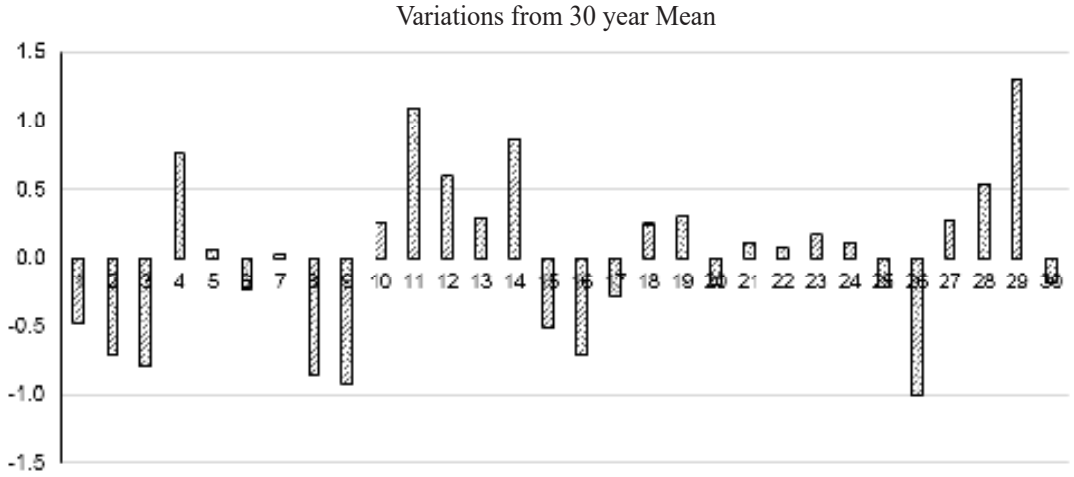

Figure 4. Variation from 30 year mean variability 1984-2014
Source: Zambia Meteorological Department

Scenario 3: Annual temperature 1974 – 2014. Figure 5 shows the overall trend of annual temperature for the period 1974-2014. Going by the trend in the figure, there was an increase in the temperatures in the District. From 1974 to 2014, temperatures increased by 1.9 ^{0}C. This translates to an increase of 0.4 ^{0}C per decade. This is consistent with the projections by Sichingabula (1998) and findings by Makano (2011). Makano (2011) stated that there has been a rise of temperature in the country by 0.3 ^{0}C per decade. The mean annual temperature reflected is 29 ^{0}C. The highest temperature which was recorded in the whole period under study was between 2010 and 2014 followed by the years between 1995 and 2000. The variations for the 40 year mean have are shown Figure 6.

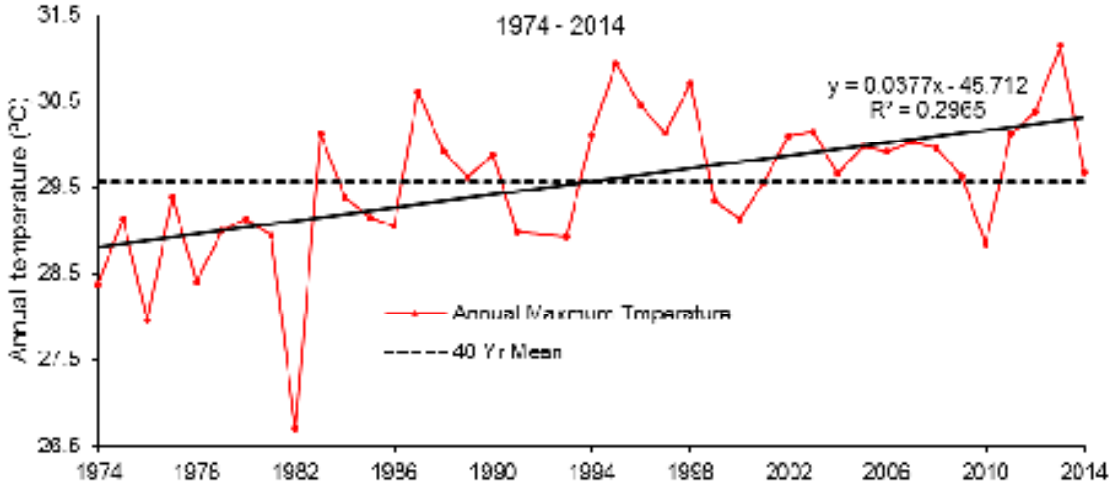

Figure 5. Five year moving average of Annual Temperature (1974 – 2014)
Source: Zambia Meteorological Department

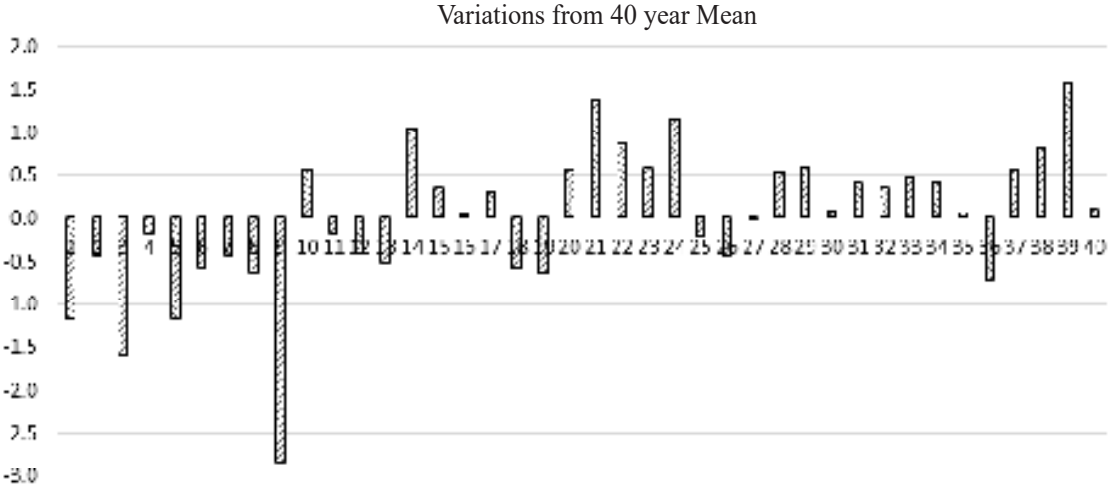

Figure 6. Variation from the 40 year mean temperature (1974-2014)
Source: Zambia Meteorological Department

Trends in crop production

Maize production 2006-2014. Although the trend shows an insignificant increase as shown in Figure 7, there was a decline in the production of maize from 2006 to 2014 for the five-year moving average of annual production. A sharp decrease of the crop (maize) production was recorded in 2006 through to 2007. The production stabilized up to 2011 where it showed an increase but declined by 2013. In 2006/2007 rain season, the reduction could be attributed to the floods (ZVAC, 2013). On the other hand, the reduction may have been due to inavailability of attribute of agricultural inputs as indicated by the respondents and the high temperatures in 2013.

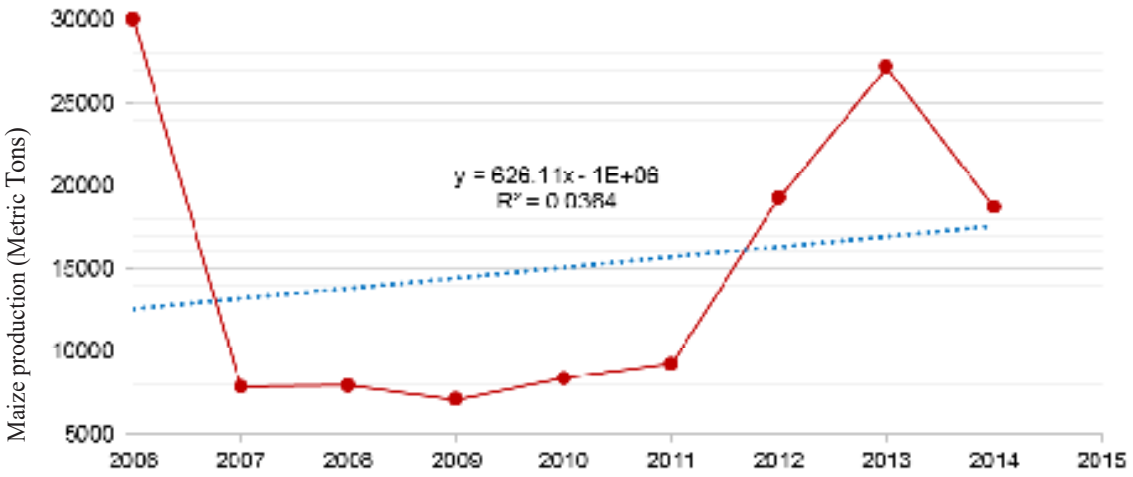

Figure 7. Annual maize production (2006-2014)

Source: Ministry of Agriculture, Zambia

Cassava production: 2006-2014. Figure 8 shows the trend for cassava production for the five-year moving average of annual production. The highest increase in production was recorded in the late 2013. It should be appreciated that cassava growing unlike for maize is not seasonal. The rise in production began in 2012 until late in 2013, but declined in 2014. The lowest production was recorded in 2009 possibly due to drought which was recorded as reported by ZVAC (2013). During 2006-2014, the five-year moving average of annual cassava production exhibited an increasing trend.

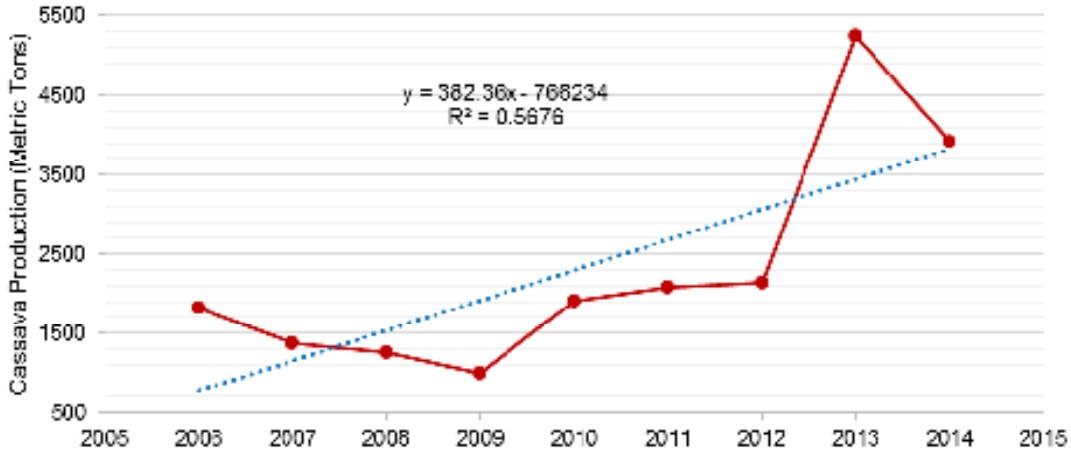

Figure 8. Annual cassava production (2006-2014)

Source: Ministry of Agriculture, Zambia

Impact of climate variability on maize and cassava production. An effort was made to investigate the probable linkage between the climate variability and change and trends in maize and cassava production. For this part of analysis, the production data of maize and cassava were used to map the trend of production in response to the annual temperature and the amount of total rainfall for the period 2006 to 2014.

Temperature vs maize production. Figure 9 is a scatter graph of temperature against maize production. Maize production was directly proportional to the rise in temperature. The graph shows that as the temperature increased, there was an increase in the production of maize.

Temperature vs cassava production. Figure 10 is a scatter graph of temperature against cassava production. The graph shows that cassava production is directly proportional to the rise in temperature. As the temperature increased, cassava production increased.

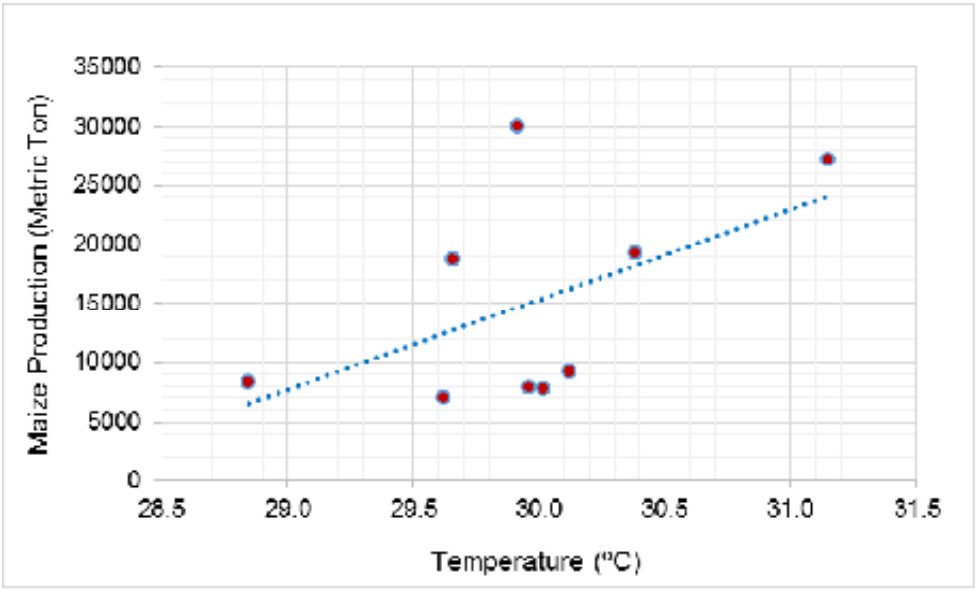

Figure 9. Annual variation in maize production Vs annual temperature from 2006-2014

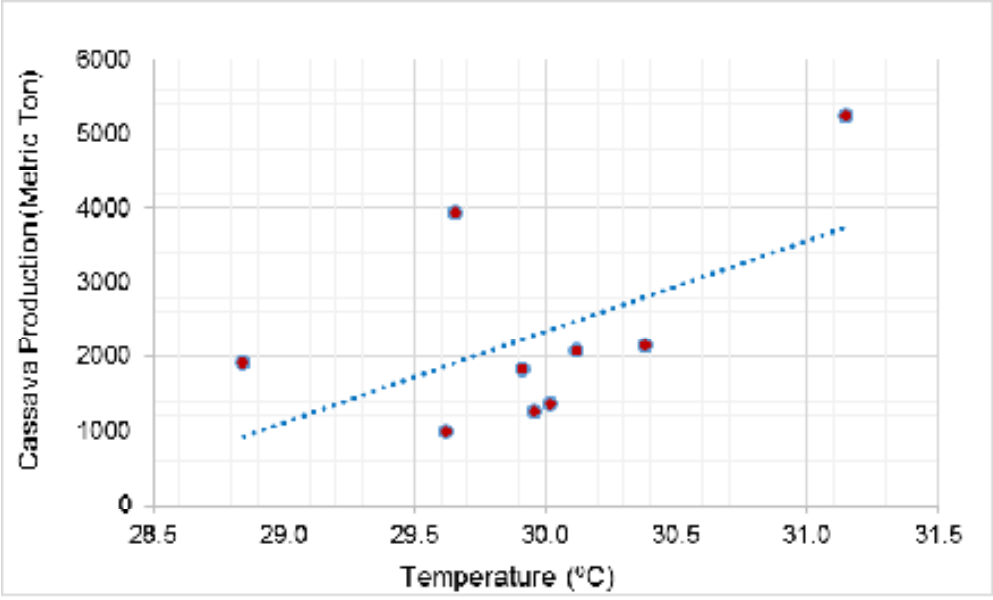

Figure 10. Annual variation in cassava production Vs Annual temperature from 2006 to 2014

Discussion

In this study, the variability and trend analysis of temperature data in Kaoma, Zambia was carried out first to understand the variation of temperature over time and to ascertain in statistical terms whether the observed time trend in temperature was significant or insignificant over the period 1974-2014. The data for analysis were obtained from the Zambia Meteorological Department. Results indicate that from 1974 to 2014, there had been an increase in temperatures in Kaoma District (see Figure 5). The indicated rise in temperature is consistent with the projections by Sichingabula (1998). The range for the total mean annual temperature rise computed for the entire period under review was 4.4 ^{0}C. The annual normal average temperature computed for the period under review was 29.5 ^{0}C (see Figure 5).

Nevertheless, there have been fluctuations which showed a high degree in temperatures (to rise in the District (see Figures 3 and 5). This indicates climate variability in the area with its negative effect on cassava and maize production.

Conclusion

Based on the findings from this study, Climate change and variability has impacted food productivity in Mayukwayukwa Refugee Settlement as shown by the link between climatic variations and food productivity in area. This is also supported by the recorded frequency of dry spells, late onset and early withdrawal of the rains with an increase in the temperature changes. High temperatures and seasonal dry spells have reduced effected crop yield which has impacted negatively the people in the Refuge camp.

The study points to the need for environmental plans, programmes and policies for climate change mitigation in Mayukwayukwa.

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