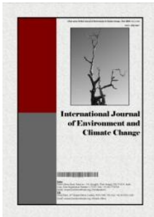

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Climate Variability and Food Crop Production in Rural Cameroon: The Case of Ejagham Community - Manyu Division

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Authors' contributions

This work was carried out in collaboration between both authors. Author RNMN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author TPB assisted in data collection and analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

This study set to establish the relationship between rainfall and temperature variabilities and food crop production in the Ejagham community, Cameroon. Data were collected for crop production in the area from 2006-2015, and for rainfall and temperature from 1975 – 2015. Variance means was used to analyse the trend in climatic conditions of rainfall and temperature while correlation coefficient was used to establish the relationship between climatic conditions and food crop production. Findings revealed that the trend in rainfall has been fluctuating. Clearly, rainfall dropped in the years 1986, 2001, 2003 and 2015. Overall, there has been a decrease in annual rainfall from about 3,000 mm in 1975 to almost 2,000 mm in 2015. The highest temperature was recorded in the 2010 with 29.0°C, followed by the year 2013 with 28.2°C. 2015 recorded the least temperature which had an average of 26.0°C. Furthermore, there exist a relationship between

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rainfall and temperature variabilities and food crop production in Ejagham area. This is indicated in the almost negative coefficients both for rainfall and temperature. It can therefore be concluded that there is a statistically significant relationship between rainfall and temperature variabilities and food crop production in Ejagham area.

Keywords: Rainfall; temperature; variabilities; food crop production; food security; Ejagham community; Cameroon.

1. INTRODUCTION

In the late 20th and early 21st Centuries, climate change and variability are pushed by or accentuated by both natural and anthropogenic interferences. Natural processes such as volcanic eruptions (scattering particles) and changes in the solar luminosity and anthropogenic (human) interferences such as the burning of fossil fuels which increase Greenhouse gases (GHGs) and burning of biomass (scattering particles) greatly impact on climate system [1,2]. Human activities are the cause of high concentration of Greenhouse gases (GHGs) such as carbon dioxide, methane and carbon monoxide in the atmosphere and this greatly affects variations in climate. The IPCC [3,4,5,6] reported that global climate is experiencing change due to increase in gaseous emissions caused by the burning of fossil fuels on the one hand and deforestation on the other.

At the global level, climate variability and change may have an overall negligible effect on total food production [7,8,9]. However, the regional impacts are likely to be substantial and variable, with some regions benefiting from an altered climate and other regions adversely affected [10,11,12,13]. Generally, food production is likely to decline in most critical regions such as the subtropical and tropical areas, whereas agriculture in developed countries may actually benefit where technology is more available and if appropriate adaptive adjustments are employed. As observed by Chijioke et al. [14] and Poudel and Shaw [15,16,17,18,19] one of the major growing concerns at the global scale and most especially in Sub-Saharan Africa is climate change which is further accentuated by globalisation.

Agriculture is the mainstay of the Cameroonian economy [20]. About 45% of Cameroon's Gross Domestic Product originates from agriculture, with close to 80% of the labour force employed in this sector [21,22,23,24]. Most importantly, this sector is also responsible for providing food security to both the rural and urban populations from domestic production [20]. The country's two rainfall regimes (unimodal and bimodal) show a gradual reduction in amount from the coastal region in the south to the Chad plain in the north [25,26]. The agricultural agenda and capacity to grow enough food for households highly depends on climatic stability. Any changes in the weather conditions could have corresponding negative impacts on crop yields and farm outputs. A shift in climatic parameters would imply some slight alteration of the agro-ecological zones. Such a shift would call for a change in the types of crops cultivated, towards grain crops or cereals which require less rainfall and have a short growing season [26]. The risks associated with increasing climate variability pose technological and economic challenges to societies which highly depend on agriculture for their livelihood. In South-western Cameroon, the natural variability of rainfall and temperatures contribute to variability in agricultural production and food insecurity [27,28].

There are a few studies conducted on the impact of climate change in agriculture in developing countries and effects of climate change on crop production in Cameroon [20] but so far nothing has been done on the impact of rainfall and temperature variabilities on food crop production in the Ejagham community. This study therefore assessed the impact of rainfall and temperature variabilities on food crop production in the Ejagham community, South West Region of Cameroon. It is also essential to establish the relationship between rainfall and temperature variabilities and food crop production in the Ejagham Community.

2. MATERIALS AND METHODS

2.1 Study Area

The Ejagham community is located in the Eyumojock Subdivision which is found in Manyu Division of the South West Region of Cameroon, some 45 km from Mamfe the capital of Manyu Division. The municipality is situated between the towns of Ikom in Nigeria and Mamfe in Cameroon figuring as one of the border councils in the Republic. It shares its western boundary with the Federal Republic of Nigeria, Akwaya lies in the north, Upper Bayang and Mamfe Central occupies the eastern boundary while the south is shared with the Mundemba and Toko councils. It extends from latitudes 5°20N and 5°87N of the equator and longitudes 8°70E and 9°08E of the Greenwich Meridian (Fig. 1).

It covers a total surface area of approximately 3,442 km^2 benefiting from three Forest Management Units which include FMU 11001, 11003 and 11005 [29].

2.2 Conceptual Framework

The conceptual framework of the study is illustrated in Fig. 3. The factors under study were the drivers of climate change, impact of climate variability on crop production, how food crop production affects food security and adaptation strategies to agriculture under changing climate variables.

2.3 Experimental Design

The study examined seasonal and annual rainfall and temperature patterns over a 40 year span (1975-2015) and food crop production for 9 years (2007-2015) in the Ejagham community in Manyu Division of Cameroon. Due to the unavailability and paucity of food crop production data for the years leading up to 2007, the authors relied on data from 2007-2015.

A quantitative design was used so as to make use of data with numerical values in order to correlate the relationship between rainfall and temperature variabilities with food crop production. The Manyu Division has 66 villages with an estimated population of 46,771 inhabitants partitioned into three clans, thus, Central Ejagham, Ejagham Njemaya and Obang [29]. Villages were selected based on the size of their populations and accessibility.

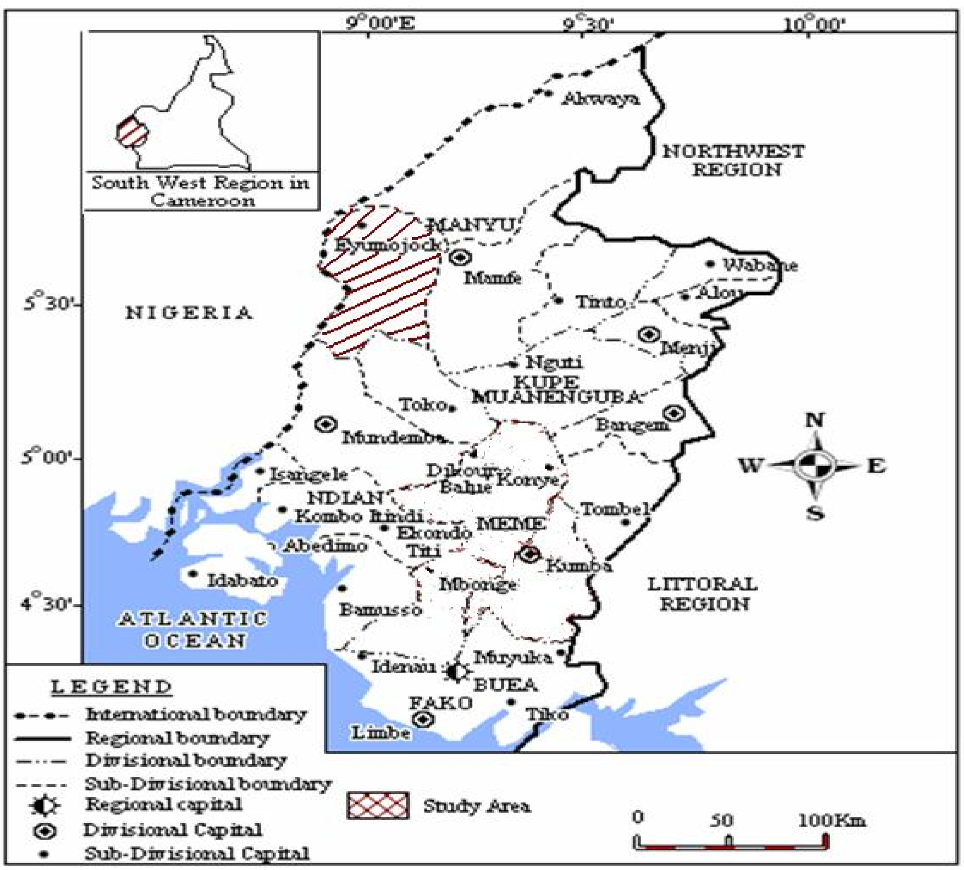

Fig. 1. The Location of the Ejagham Area in the South West Region of Cameroon
Source: Adopted from Lands and Survey, Mamfe, (2011)

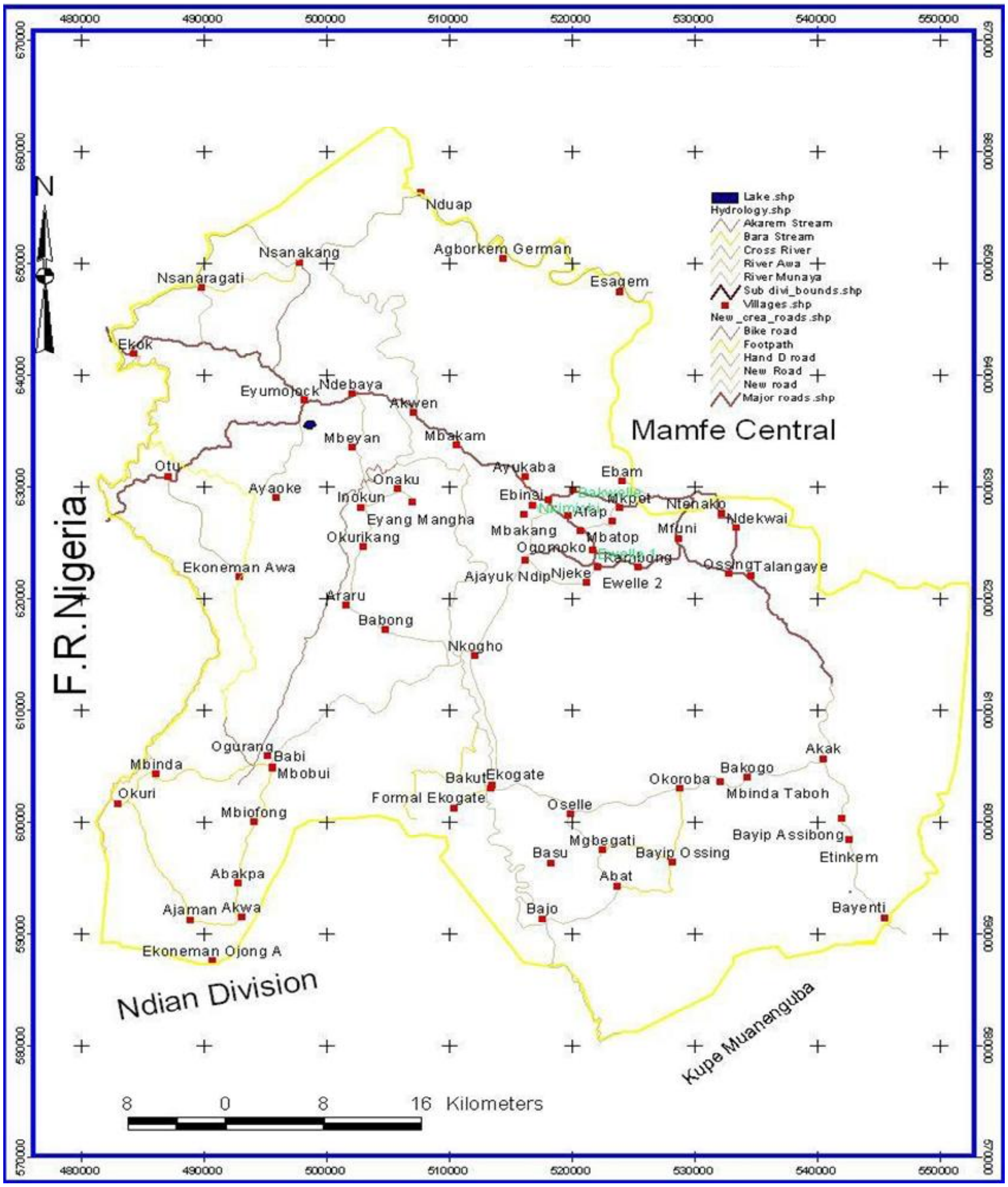

Fig. 2. Map of Eyumojock Municipality

2.4 Data Collection on Rainfall, Temperature and Food Crops

Rainfall and temperature data were collected for a forty years period from Besongabang Weather Station [30,31] and information on crop yields collected for nine years from the Divisional Delegation of Agriculture and Rural Development for Eyumojock [32]. Data were collected for specific crops that are mostly grown in the area. The crops under study included cassava, cocoyam, plantains, banana, maize, egusi and yams. Past documents from the Sub-Delegation of Agriculture and Rural Development and the Council in Eyumojock were very useful in conducting this study. These documents presented the physical and economic background information of the study area, the practice of agriculture and challenges involved. This was an important source of data, which addressed the main theme of the study, that is, climate variability.

2.5 Statistical Analysis

Simple comprehensive statistical techniques were used to present data for easy understanding. Variance means was used to analyse the trend in climatic conditions of rainfall and temperature while correlation relationship was used to establish a relationship between climatic conditions and food crop production. Percentage mean deviation and averages were used to produce variabilities and trends in climatic conditions for the duration of the study. These trends were further depicted on graphs showing annual rainfall and temperature trends, line graphs to show variability of climatic conditions and crop production. In order to show variability, the standard deviation was used.

$$\text{Standard deviation } (\delta) = \sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$$

In order to correlate the variability of climatic conditions and crop production, the correlation coefficient (r) was used. This is given by:

$$r = \frac{\frac{1}{n}\sum\left(X-\overline{X}\right)\left(Y-\overline{Y}\right)}{\sqrt{X}\sqrt{Y}}$$

The student t-test was used to compare the calculated value with the table value in order to verify if the relationship must have occurred by chance or not. This is given by:

$$\text{t-test} = \frac{r \cdot \sqrt{n-2}}{\sqrt{1-r^2}}$$

In summary, inferential statistics was also used to help establish the relationship between the variables under study. The analysed data was presented qualitatively in prose form and diagrammatically using appropriate charts and figures.

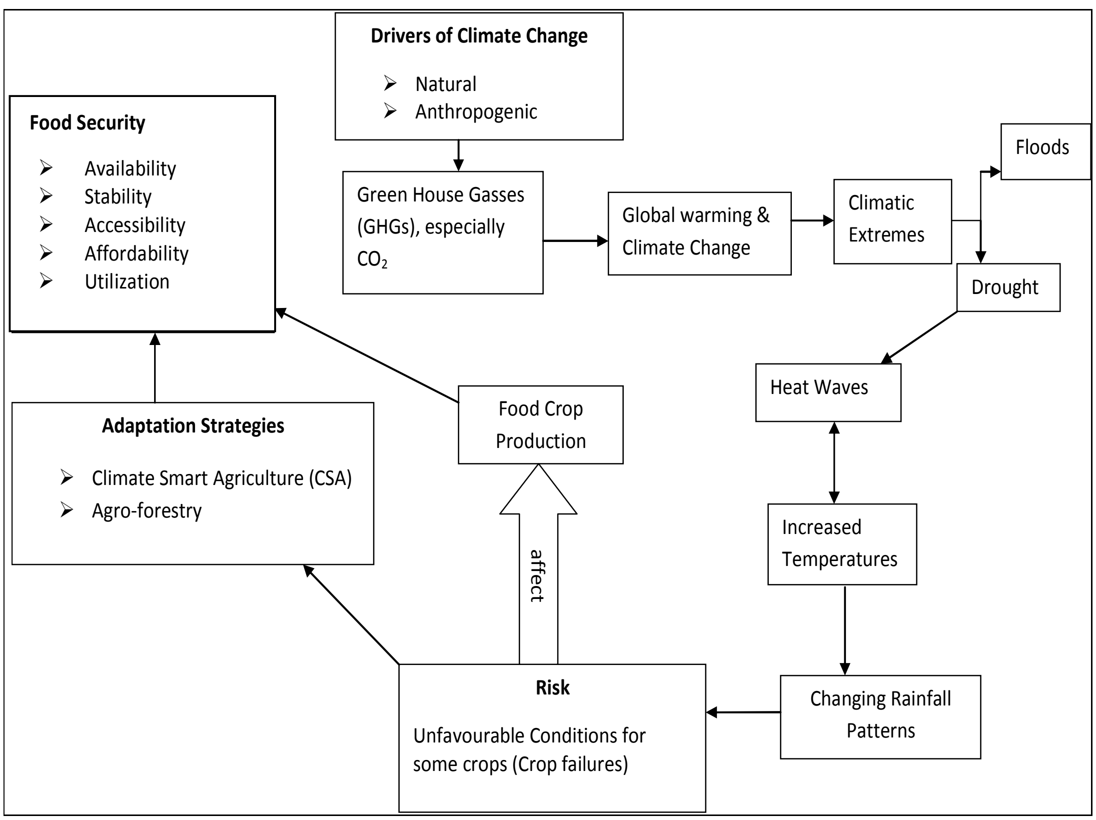

Fig. 3. Conceptual Framework on the dependency of Food Crop Production on Climate Variables

3. RESULTS AND DISCUSSION

3.1 Analysis of Rainfall Data

Rainfall data were collected from Besongabang Weather Station for the period from 1975 to 2015. The trend was established and presented on Fig. 4. From the graph, the trend of rainfall has been fluctuating. Rainfall figures dropped in the years 1986, 2001, 2003 and 2015. There also existed years with increase in the trend of rainfall. Years like 1976, 1997 and 2013 experienced remarkable increase in the trend of rainfall in the Ejagham area. However, from 2014 to 2015, there has been a decrease in the amount of rainfall received in the Ejagham area. Overall, there has been a noticeable decrease in annual rainfall from about 3,000 mm in 1975 to almost 2,000 mm in 2015. This is a significant drop of about 1,000 mm of rainfall over this period.

From 2006 to 2015, the highest rainfall was recorded in the year 2013 with an average of 3543.7 mm while the lowest was recorded in 2015 which had an average of 2032.3 mm (Fig. 5). The year 2013 should naturally present a favourable year for food crops in this area as they need enough water to survive.

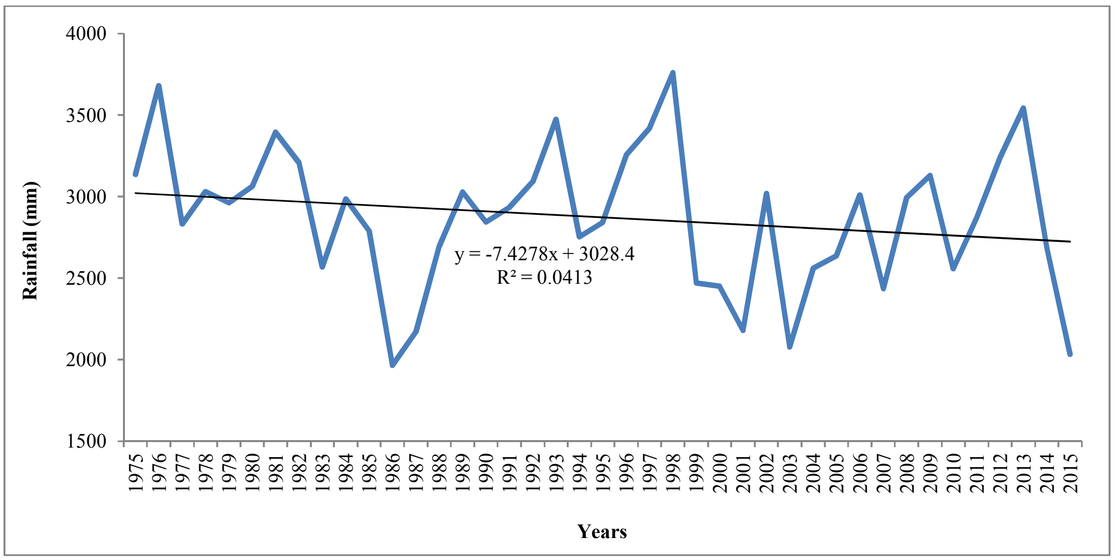

Fig. 4. Annual Rainfall Trend from 1975 – 2015 for Ejagham Area
Source: Culled from data from [30,31].

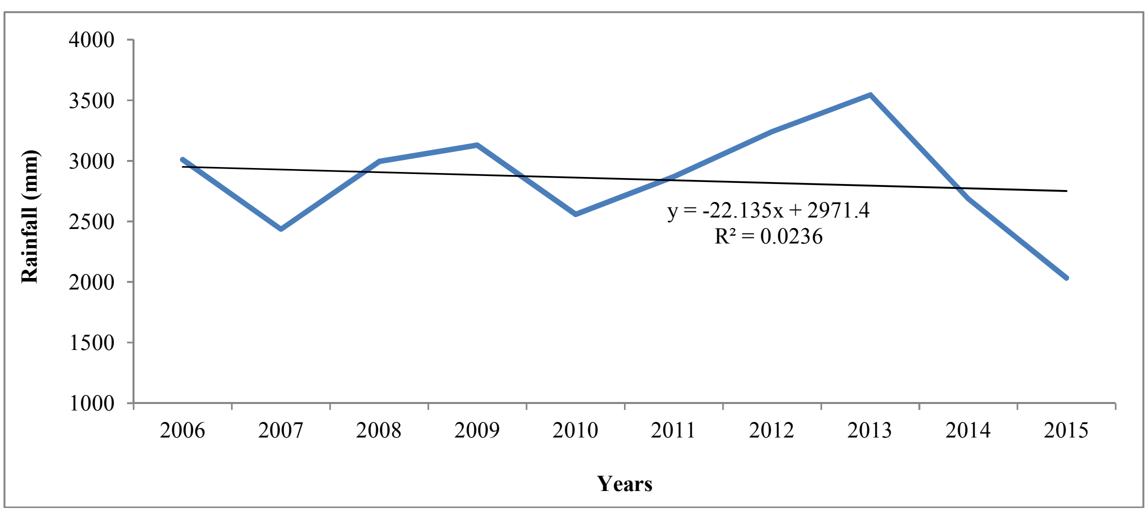

Fig. 5. Annual Rainfall Variability from 2006-2015 for Ejagham Area
Source: Culled from data from [30], [31].

3.2 Analysis of Temperature Data

The highest temperature from 2006 to 2015 was recorded in 2010 with an average of 29.0 degrees Celsius, followed by 2013 which recorded an average of 28.2 degrees Celsius (Figs. 6-7). All these present an unfavourable condition for plant growth. In the year 2015 which recorded the least temperature which had an average of 26.0 degrees Celsius and presents favourable conditions for plant growth. The years 2012 and 2015 presented very favourable temperatures for plant growth.

3.3 Presentation of Food Crop Production Data for Eyumojock Sub Division

Food crop production has been progressively increasing for almost all crops over the years 2007-2015, except for egusi that experienced a drastic fall in production in the year 2015 (Figs. 8-14). Cassava production has been slowly but steadily increasing over the years in the Ejagham area with its highest production being recorded in 2015 (160,215 tons) (Fig. 8).

The production of cocoyam, just like that of cassava, has been increasing in a slow but consistent pace in the Ejagham area from 2007 to 2012. However, in 2013, the increase in production became really high and significant with highest recorded in 2015 (6,627 tons) (Fig. 9).

The production of plantains in 2007 was 7,846 tons and in 2008, it experienced an increase of above a thousand ton when it recorded 8,912 tons in production. The increase in the number of tons dropped to below four hundred tons when the production shifted from 8,912 in 2008 tons to 9,297 tons in 2009. There existed a remarkable increase in the production of plantains in 2010 when the difference between production in 2009 and 2010 was above 2,500 tons (that is, a shift from 9297 tons in 2009 to 11,872 tons in 2010). The difference in production between 2010 and 2011 is 1,154 tons (that is; shift in production from 11,872 tons in 2010 to 13,026 tons in 2011). In 2012, there was an increase in production of plantains by 2,286 tons when it shifted from 13,026 tons in 2011 to 15,312 tons in 2012. The difference in production from 2012 to 2013 is 2,753 tons in plantain production as the curve shifts from 15,312 tons in 2012 to 18,065 in 2013. The difference in production between 2013 and 2014 is significantly low as it recorded only 385 tons increase (that is; from 18,065 tons in 2013 to 18,450 tons in 2014). The production curve shifted from 18,450 tons in 2014 to 21,145 tons in 2015, giving an increase in 2,695 tons. From the analyses, 2015 recorded the highest production in plantains (Fig. 10).

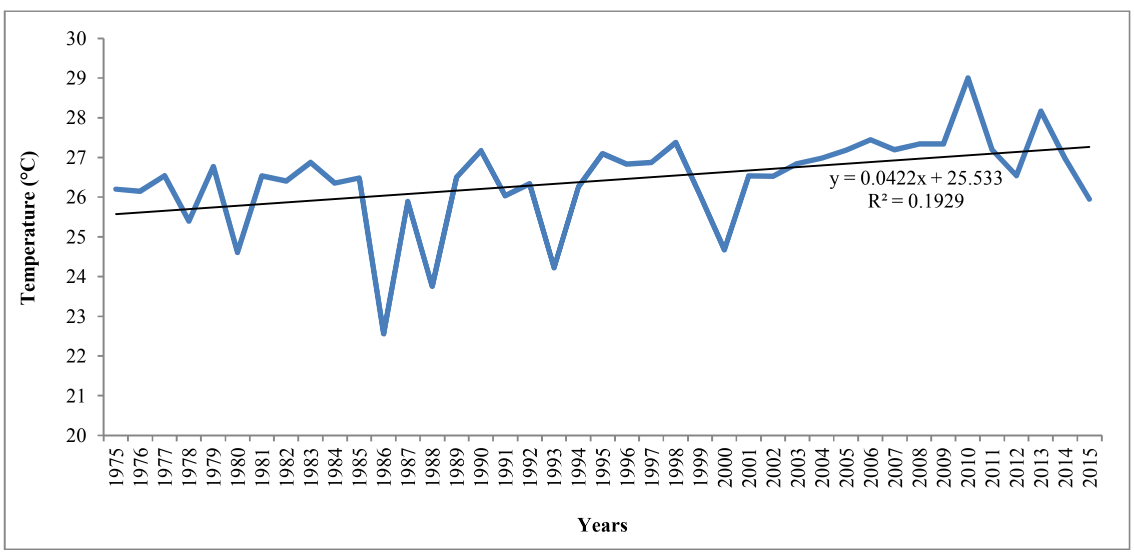

Fig. 6. Annual Temperature Variability from 1975-2015 for Ejagham Area

Source: Culled from data from [30], [31].

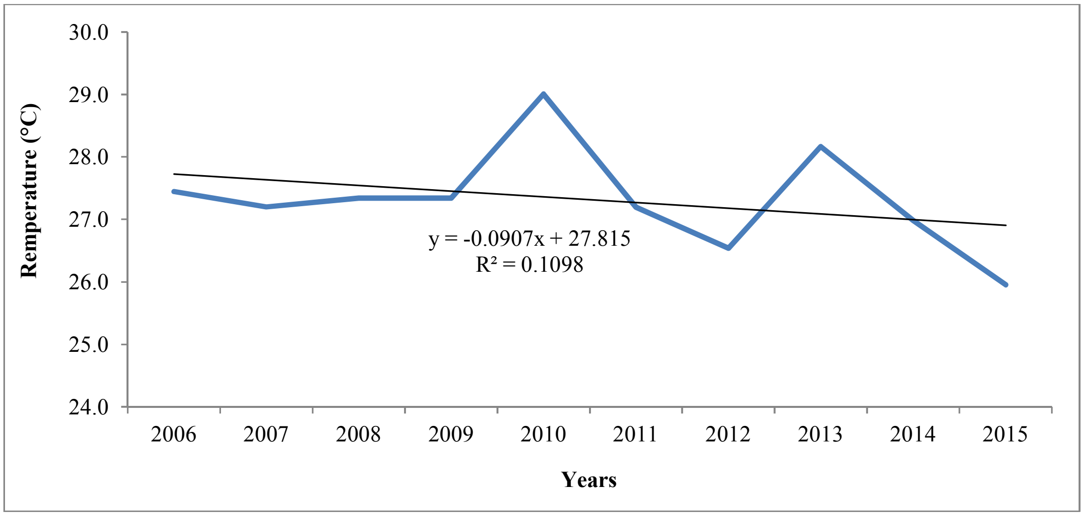

Fig. 7. Annual Temperature Variability from 2016-2015 for the Ejagham Area
Source: Culled from data from [30], [31].

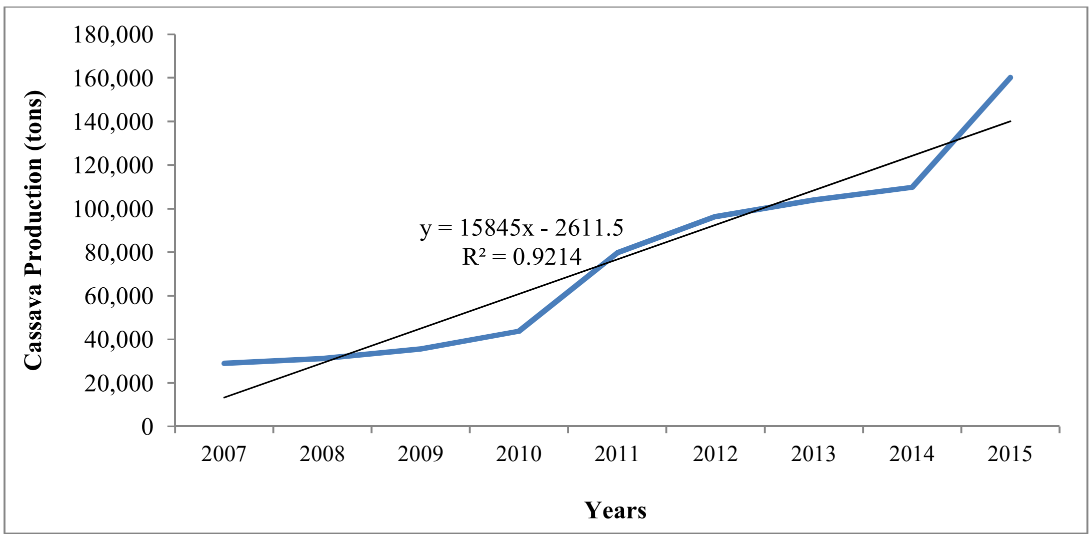

Fig. 8. Trend of Cassava Production from 2007-2015 for the Ejagham Area
Source: [32]

Banana production in 2007 was 2,789 tons and it moved to 3,012 tons in 2008, giving an increase of 223 tons in production. In 2009, the production curve shifted upward with an increase of 677 tons (that is; from 3,012 tons in 2008 to 3,689 tons in 2009) in production. In 2010 the increase in production wasn't as high as that experienced in 2009; the increase was 322 tons as production moved from 3,689 tons in 2009 to 4,011 tons in 2010. The difference between production in 2010 and 2011 gives us 831 tons as the curve moved from 4,012 tons in 2010 to 4,842 tons in 2011. The production curve gradually moved from 4,842 tons in 2011 to 5,092 tons in 2012; giving a small increase of 250 tons in the production of banana. The year 2013 came with a far more significant increase in the production of banana as the increase went up to 1,208 tons (that is; from 5,092 tons in 2012 to 6,300 tons in 2013). A remarkable increase was recorded in 2014 as the production curve moved from 6,300 tons in 2013 to 8,246 tons in 2014, giving an increase of 1,946 tons. So far, 2015 was the year which recorded the highest production of banana crop. The curve kept moving upward from 8,246 tons in 2014 to 10,564 in 2015 which gave an increase of 2,318 tons in banana production (Fig. 11).

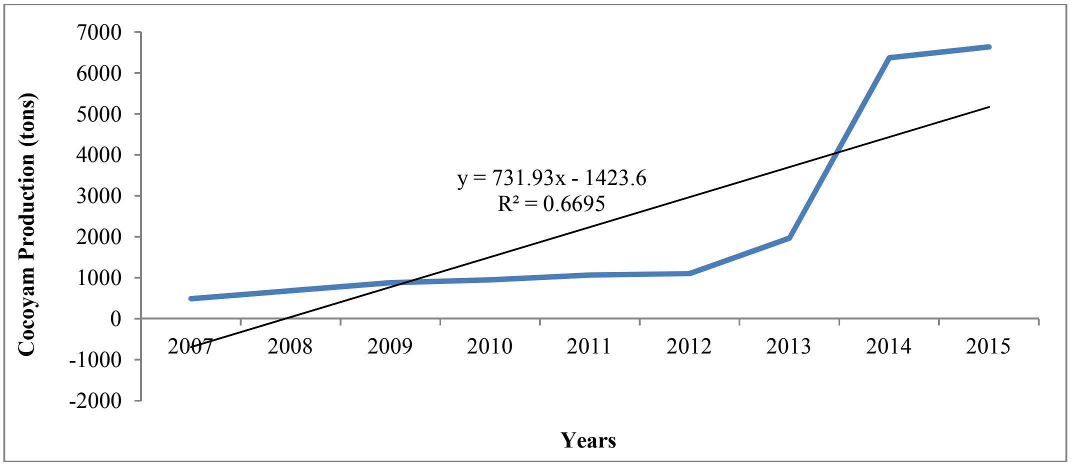

Fig. 9. Trend of Cocoyam Production from 2007-2015 for the Ejagham Area
Source: [32]

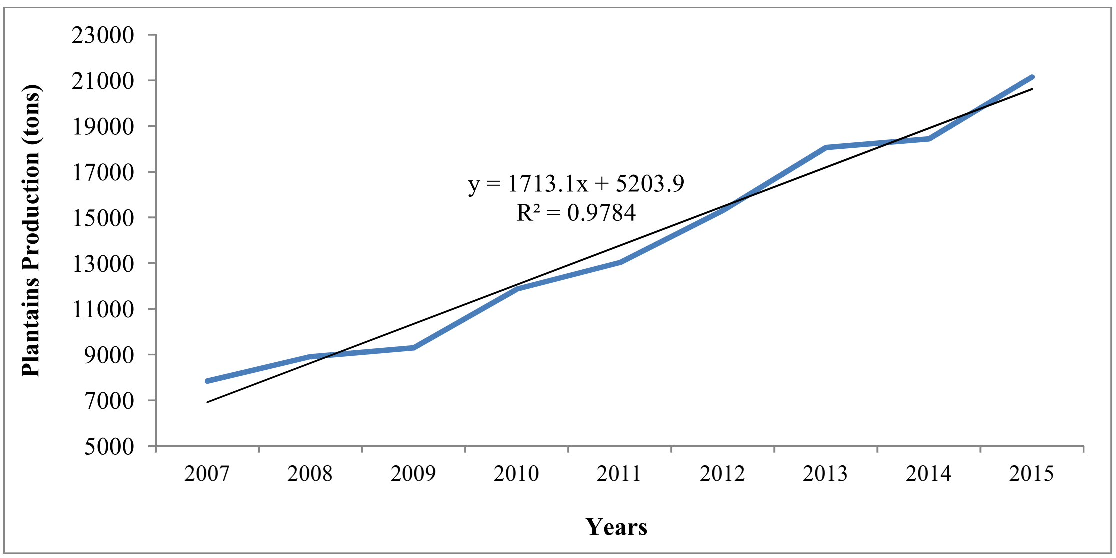

Fig. 10. Trend of Plantains Production from 2007-2015 for the Ejagham Area
Source: [32]

Maize production was 711 tons in 2007. And there was an increase in production from 711 tons in 2007 to 836 tons in 2008, recording an increase of 125 tons. There was a mild increase in production from 2008 to 2009 as the increase was just 64 tons (that is; from 836 tons in 2008 to 900 tons in 2009). 2010 did not experience much increase just like 2009 as the increase was just 79 tons when the production moved from 900 tons in 2009 to 979 tons in 2010. The increase in production in 2011 is low as it recorded only 32 tons increase with the shift from 979 tons in 2010 to 1,011 tons in 2011. The increase in the production on Maize in 2012 was 273 tons as the curve shifted from 1,011 tons in 2011 to 1,284 in 2012. The curve moves a little upward as production moves from 1,284 tons in 2012 to 1,424 tons in 2013; recording a 140 tons increase in production. The year 2014 presented a very high increase in the production of Maize as the curve moves from 1,424 tons in 2013 to 1,714 tons in 2014; recording an increase of 290 tons in production. The increase in 2015 is 175 tons as production shifted from 1,714 tons in 2014 to 1,889 tons in 2015. The year which recorded the highest production in Maize is 2014 which had an increase of 290 tons (Fig. 12).

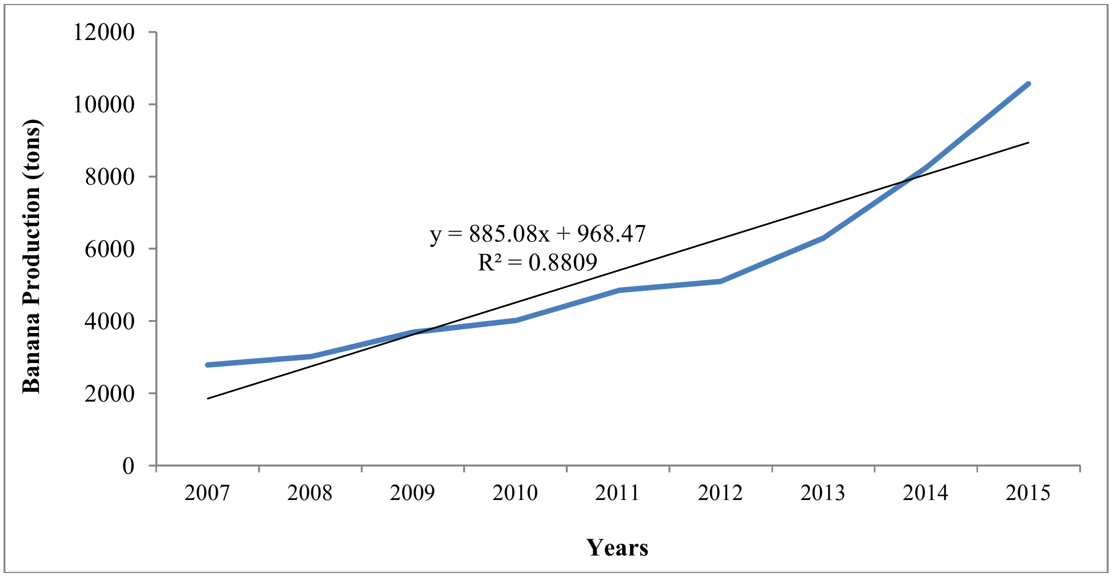

Fig. 11. Trend of Banana Production from 2007-2015 for the Ejagham Area
Source: [32]

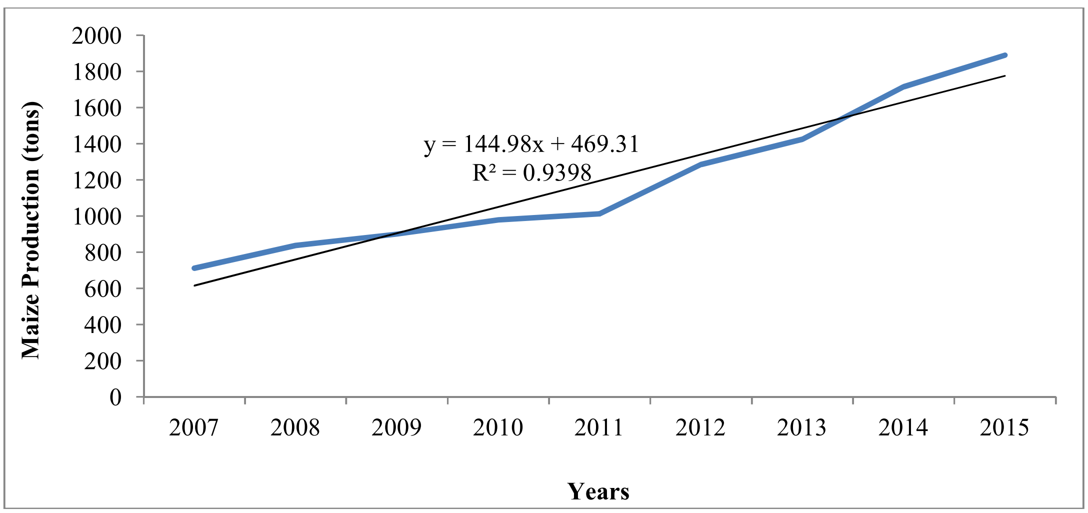

Fig. 12. Trend of Maize Production from 2007-2015 for the Ejagham Area
Source: [32]

The production of yams has been increasing constantly from 2,108 tons in the year 2007 to 6,497 tons in 2015. The production of yams moved from 2,108 tons in 2007 to 2,856 tons in 2008, recording an increase of 748 tons. The curve keeps moving upward from 2,856 tons in 2008 to 3,169 tons in 2009 which recorded a 313 tons increase in the production of yams. The production moved from 3,169 tons in 2009 to 3,774 tons in 2010, which recorded an increase of 605 tons from the previous yields. The production curve keeps moving upward with a shift from 3,774 tons in 2010 to 4,012 tons in 2011 recording an increase of 238 tons. A 550 increase in tons of yams was recorded in 2012 as production moved from 4,012 tons in 2011 to 4,562 tons in 2012. The curve moves from 4,562 tons in 2012 to 5,287 tons in 2013 which gives an increase of 725 tons in production. In 2014, the production of yams experienced an increase of 462 tons as the curve moved from 5,287 tons in 2013 to 5,713 tons in 2014. And 2915 experienced the highest increase in the production of yams as it recorded 784 tons increase with the movement of the curve from 5,713 tons in 2014 to 6,497 tons in 2015 (Fig. 13).

Production of Egusi stood at 3,019 tons in 2007 and it moved to 3,847 tons in 2008 which recorded 828 tons. The production increases by 164s ton when production shifted from 3,847 tons in 2008 to 4,011 tons in 2009. The increase in production in 2010 was recorded at 455 tons as production moved from 4,011 tons in 2009 to 4,466 tons in 2010. The curve continues to run upward as production experiences an increase from 4,466 tons in 2010 to 5,009 tons in 2011; recording an 543 tons increase. The production of Egusi keeps increasing with the coming of each year; 2012 recorded an 879 tons increase in Egusi production as the curve moved from 5,009 tons in 2011 to 5,888 tons in 2012. The Egusi production curve continues to move upward with increase from 5,888 tons in 2012 to 6,778 tons in 2013; recording an increase in 890 tons. The year 2014 happened to be the most favourable for Egusi production as the curve moved from 6,778 tons in 2013 to 7,971 tons in 2014; recording a remarkable increase of 1,193 tons. In 2015, production of Egusi experienced a fall as the curve drops down, recording a negative return in Egusi production from 7,971 2015 in 2014 to 841 tons in 2015 (Fig. 14). The next session focuses on presenting findings based on the regression analyses.

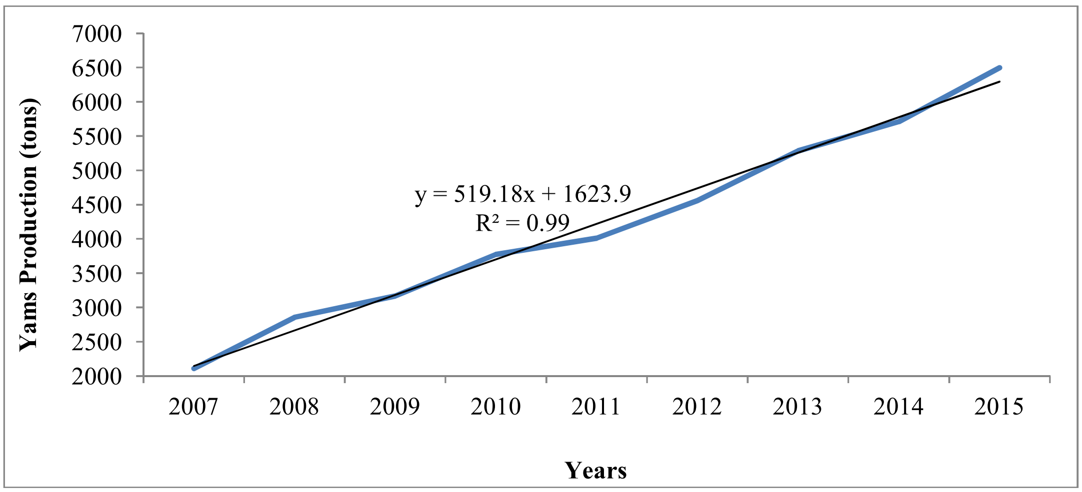

Fig. 13. Trend of Yam Production from 2007-2015 for the Ejagham Area
Source: [32]

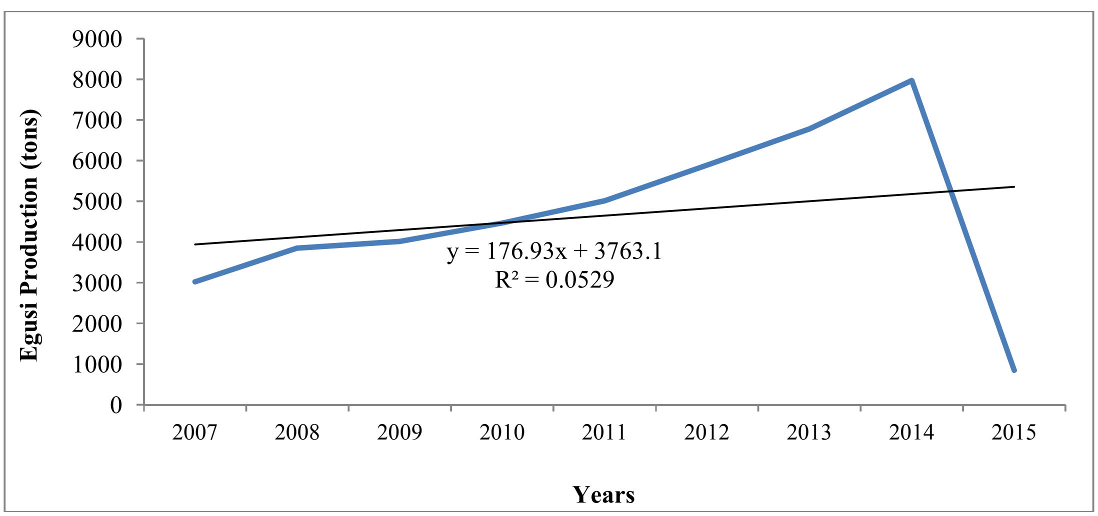

Fig. 14. Trend of Egusi Production from 2007-2015 for the Ejagham Area
Source: [32]

3.4 Regression Analyses

The regression analyses were conducted to establish the relationship between crop types, temperature coefficient and rainfall coefficient (which are indicators of climate variability). The results were presented in terms of the adjusted R^2 (or measure of best fit) and the probability or P-values (Table 1). The regression analyses show the individual climatic effects on the output of the various crops. The effects of rainfall and temperature on crop production were analyzed separately.

3.5 Interpretation of the Cassava Model

The coefficient for temperature is negative. It shows that an increase in temperature will lead to a fall in the output of cassava. This is true because it is in line with agricultural expectation by agriculturalist which establishes a negative relationship between tuber crops and the soil temperature. Although temperature (heat) is needed for the growth of plants, when it exceeds a certain level, it becomes detrimental to the growth and productivity of the plant. The coefficient is -9.15 showing that a unit increase in temperature leads to a 9.15 fall in cassava output. In this case it can be concluded that higher than normal temperatures have a negative effect on cassava output in the Ejagham region. Looking at p-value showed that this relationship is not significant. In effect, this means that it is not conclusive for us to associate the production of cassava only to the temperature, but other variables like the fertility of the soil, the care given to the crops are also important determinants.

The coefficient for rainfall is negative. It shows that an increase in rainfall will lead to a fall in the output of cassava. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and soil moisture. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient of 0.14 showed that a unit increase in rainfall leads to a 0.14 fall in cassava output. In this case it can be concluded that higher than normal rainfalls have a negative effect on cassava output in the Ejagham region. Looking at p-value showed that this relationship is not significant. In effect, it means that it is not conclusive to associate the production of cassava only to the rainfall, but other variables like the fertility of the soil, the care given to the crops are also important determinants. The R^2 showed that in the cassava model, both rainfall and temperature account for about 17.5% of all the variations in cassava output and about 87.5% is accounted for by human factors and soil fertility.

3.6 Interpretation of the Cocoyam Model

The coefficient for temperature is negative. It shows that an increase in temperature will lead to a fall in the output of cocoyam. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and the soil temperature. Although temperature (heat) is needed for the growth of plants, when it exceeds a certain level, it becomes detrimental to the growth and productivity of the plant. The coefficient of -9.84 shows that a unit increase in temperature results to a -9.84 fall in cocoyam output. In this case we can see how higher than normal temperatures have a negative effect on cocoyam output in the Ejagham region. Looking at p-value of 0.1464 showed that this relationship is not significant. In effect, it means that it is not conclusive to associate the production of cocoyam only to the temperature, but other variables such as the fertility of the soil and the care given to the crops among others are also important determinants.

Table 1. Summary table

Crop	Temperature (Coefficient)	Rainfall (Coefficient)	R^2(Adjusted) (Measure of Best Fit)	P -Value
Cassava	-9.145566	-0.140567	0.173146	0.1464
Cocoyams	-9.846824	-1.622144	0.224216	0.1827
Plantains	-3.432481	-0.210705	-0.175703	0.2116
Maize	4.124062	-0.231262	0.151849	0.1520
Banana	-5.342871	0.598712	0.195548	0.1331
Yams	-3.294444	-0.200625	0.068112	0.2804
Egusi	5.187669	2.499460**	0.570827	0.1405

*** Variable is significant at 5 % level of significance*

The coefficient for rainfall is negative. It shows that an increase in rainfall will lead to a fall in the output of cocoyam. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and soil moisture. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient of 1.62 indicates that a unit increase in rainfall results to a 1.62 fall in cocoyam output. In this case it can be seen that higher than normal rainfall has a negative effect on cocoyam output in Ejagham region. Looking at the p-value, it shows that this relationship is not significant. In effect, it is not conclusive to associate the production of cocoyam only to the rainfall, but other variables like the fertility of the soil and the care given to the crops are also important. The R^2 shows that in the cocoyam model, both rainfall and temperature account for about 22.4% of all the variations in cocoyam output and about 78.6% is accounted for by human factors and soil fertility.

3.7 Interpretation of the Plantains Model

The coefficient for temperature is negative. It shows that an increase in temperature will lead to a fall in the output of Plantains. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between plantain suckers and the soil temperature. Although temperature (heat) is needed for the growth of plants, when in exceeds a certain level, it becomes detrimental to the growth and productivity of the plant. The coefficient is -3.43 showing that a unit increase in temperature accounts for a 3.43 fall in plantains output. In this case, it can be seen that higher than normal temperatures have a negative effect on plantains output in the Ejagham region. Looking at the p-value of 0.1827, it shows that this relationship is not significant. In effect, it is not conclusive for use to associate the production of plantains only to the temperature, but other variables like the fertility of the soil and the care given to the crops are also important.

The coefficient for rainfall is negative. It shows that an increase in rainfall leads to a fall in the output of plantains. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between plantain suckers and soil moisture. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient was 0.21 shows that a unit increase in rainfall leads to a 0.21 fall in plantains output. In this case it can be seen that higher than normal rainfall has a negative effect on plantains output in Ejagham area. Looking at the p-value, it shows that this relationship is not significant. In effect, it is not conclusive to associate the production of plantains only to the rainfall, but other variables like the fertility of the soil and the care given to the crops are also important. The R^2 shows that in the plantains model, both rainfall and temperature account for about 17.5% of all the variations in plantains output and about 83.5% is accounted for by human factors and soil fertility.

3.8 Interpretation of the Maize Model

The coefficient for temperature is positive. It shows that an increase in temperature will lead to a rise in the output of maize. This is true because it is in line with agricultural expectation by agriculturalist that see a positive relationship between cereals and temperature. Heat is required for the growth of plants, and productivity of the plant. The coefficient is 4.12 showing that a unit increase in temperature will lead to a 4.12 tons rise in Maize output. In this case, higher temperatures have a negative effect on maize output in the Ejagham region. Looking at p-value, it shows that this relationship is not significant. In effect, it is not conclusive to associate the production of maize only to the temperature, but other variables like the fertility of the soil and the care given to the crops are also important.

The coefficient for rainfall is negative. It shows that an increase in rainfall will lead to a fall in the output of maize. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and soil moisture. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient is -0.23 showing that a unit increase in rainfall will lead to a 0.23 fall in maize output. In this case higher than normal rainfall has a negative effect on maize output in the Ejagham region. Looking at p-value of 0.1520, it indicates that this relationship is not significant. In effect this means that it is not conclusive to associate the production of maize only to the rainfall, but other variables such as the fertility of the soil and the care given to the crops are also important determinants. The R^2 shows that in the maize model, both rainfall and temperature account for about 15.1% of all the variations in maize output and about 86.9% is accounted for by human factors, soil fertility.

3.9 Interpretation of the Banana Model

The coefficient for temperature is negative. It shows that an increase in temperature will lead to a fall in the output of banana. This is in line with agricultural expectation by agriculturalist that see a negative relationship between banana suckers and temperature. Cooler temperature is needed for the growth of plants and productivity of the plant. The coefficient is -5.34 shows that a unit increase in temperature results to a 4.12 tons fall in banana output. In this case higher temperatures have a negative effect on banana output in the Ejagham region. Looking at the p-value of 0.1331, it shows that this relationship is not significant. In effect, it is not conclusive to associate the production of banana only to the temperature, but other variables such as the fertility of the soil and the care given to the crops are also important.

The coefficient for rainfall is negative. It shows that an increase in rainfall leads to a rise in the output of banana. This is true because it is in line with agricultural expectation by agriculturalist that see a positive relationship between banana suckers and the soil moisture. Rainfall is needed for the growth of bananas and a drop becomes detrimental to the growth and productivity of the plant. The coefficient of 0.59 shows that a unit increase in rainfall leads to a 0.23 rise in banana output. In this case higher than normal rainfall has a negative effect on banana output in the Ejagham region. Looking at the p-value, it show that this relationship is not significant. In effect, it is not conclusive to associate the production of banana only to the rainfall, but other variables like the fertility of the soil and the care given to the crops are also important. The R^2 shows that in the banana model, both rainfall and temperature account for about 19.5% of all the variations in banana output and about 80.1% is accounted for by human factors and soil fertility.

3.10 Interpretation of the Yams Model

The coefficient for temperature is negative. It shows that an increase in temperature lead to a fall in the output of yams. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and soil temperature. Although temperature (heat) is needed for the growth of plants, when in exceeds a certain level, it becomes detrimental to the growth and productivity of that plant. The coefficient of -3.29 indicates that a unit increase in temperature leads to a -3.29 fall in yams output. In this case higher than normal temperatures have a negative effect on yams output in the Ejagham region. Looking at p-value of 0.2804, it shows that this relationship is not significant.

The coefficient for rainfall is negative. It shows that an increase in rainfall leads to a fall in the output of yams. This is true because it is in line with agricultural expectation by agriculturalist that see a negative relationship between tuber crops and the soil moisture. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient of -0.20 indicates that a unit increase in rainfall leads to a -0.20 fall in yams output. In this case higher than normal rainfalls have a negative effect on yams output in the Ejagham region. Looking at the p-value, it shows that this relationship is not significant. In effect, it is not conclusive to associate the production of yams only to the rainfall, but other variables like the fertility of the soil and the care given to the crops are also important. The R^2 shows that in the yams model, both rainfall and temperature account for about 6.8% of all the variations in yams output and about 87.5% is accounted for by human factors and soil fertility.

3.11 Interpretation of the Egusi Model

The coefficient for temperature is positive. It shows that an increase in temperature leads to an increase in the output of egusi. This is true because it is in line with agricultural expectations for egusi by agriculturalist that see a positive relationship between melons and the temperature. Although temperature (heat) is needed for the growth of egusi, the coefficient of 5.18 shows that a unit increase in temperature leads to a 5.18 increase in egusi output. In this case higher temperatures have a positive effect on egusi output in the Ejagham region. The p-value of 0.1405 shows that this relationship is very significant. In effect, it is very certain and conclusive to associate the production of egusi only to the temperature, than to other variables such as the fertility of the soil and the care given to the crops.

The coefficient for rainfall is positive. It shows that an increase in rainfall leads to an increase in the output of egusi. Rainfall is needed for the growth of plants and a drop becomes detrimental to the growth and productivity of the plant. The coefficient of 2.5 shows that a unit increase in rainfall leads to a 0.14 rise in egusi output. In this case higher rainfall has a positive effect on egusi output in the Ejagham region. Looking at the p-value, it shows that this relationship is very significant. In effect, it is conclusive to associate the production of egusi only to the rainfall, rather than to other variables like the fertility of the soil and the care given to the crops. The R^2 shows that in the egusi model, both rainfall and temperature account for about 57.1% of all the variations in egusi output and about 42.9% is accounted for by human factors and soil fertility.

3.12 Verification of the Hypothesis

This study was guided by the following hypothesis:

- **Ho:** There exists no relationship between rainfall and temperature variabilities and food crop production in Ejagham area.
- **Ha:** There is a relationship between rainfall and temperature variabilities and food crop production in Ejagham area.

Information presented on Table 1 and the ensuing discussions indicate without doubt that there exist a relationship between rainfall and temperature variabilities and food crop production in Ejagham area. This is indicated in the almost negative coefficients both for rainfall and temperature. Based on the above information, the null hypothesis is rejected and the alternative hypothesis is retained. It can therefore be concluded that there is a statistically significant relationship between rainfall and temperature variabilities and food crop production in Ejagham area. In other words, rainfall and temperature are the major determinants of food crop production in Ejagham area, and with the continuous variability in these variables, it is clear that farmers have to implement certain adaptation strategies in order to boost agricultural production. Some of these strategies which have to do with improved planting materials and application of agricultural chemicals are costly, and therefore account for the reason why a high proportion of farmers do not rely on these improved planting materials and agricultural chemicals, such as fertilizers and pesticides.

4. DISCUSSION OF FINDINGS

4.1 Relationship between Rainfall and Temperature Variabilities and Food Crop Production

Rainfall and temperature variabilities affect food crop production in the Ejagham area. This is in line with Chijioke et al. [33,34,35,36,37] that observed that food crop production is an element that is highly affected by climatic variations and besides, crops have varying sensitivity to temperature and rainfall. The study revealed that where the coefficient for crops is negative both in rainfall and temperature, an increase in the rainfall and temperature will lead to a fall in output while in the other hand, when the coefficient is positive in rainfall and temperature, an increase in them will lead to a rise in output. This aligns with what Smith et al. [38,39,40] observed that higher temperatures are harmful for food crop cultivation.

4.2 Impact of Rainfall and Temperature Variabilities on Crop Type and Effects on Food Availability

Temperature and rainfall variabilities affect crop types differently and consequently affect their availability differently. The year 2015 recorded the highest food crop production for crops like yam, banana, plantains and cassava with an annual average temperature of 26.0 degrees Celsius and rainfall of 2,032 mm in the Ejagham area. While the year 2014 recorded the highest food productions for crops like egusi, maize and cocoyam with an annual average temperature of 27.0 degrees Celsius and rainfall of 2,684 mm. This means that lower temperatures (26.0 degrees Celsius) and a unit decrease in rainfall (2,032.3 mm) jointly affect tuber crops like cassava and cocoyam and perennial crops such as plantains and banana production in a positive way in the Ejagham.

Findings revealed that egusi is the main food crop that is highly affected by the combined effects of rainfall and temperature variabilities in the Ejagham area as both the rainfall and temperature account for about 57.1% of all the variations in the output of egusi. Meanwhile the food crop that is least affected by rainfall and temperature variabilities is yam as both rainfall and temperature account for about 6.8% of all the variations in the output of yams.

On a similar vein, food crops had varying years that their production was negatively affected with the variabilities in temperature and rainfall. In 2008 for example, the production of banana and cassava were at their lowest with an annual average temperature of 27.3 degrees Celsius and an annual rainfall of 2,993.3 mm. This means that higher temperatures negatively affect the production of banana and cassava in the

Ejagham area. Thus, the availability of those food crops was reduced as availability strongly depends on production.

5. CONCLUSION

From the results of this study, it accepted the alternative hypothesis that was set for this study which stated that there is a relationship between rainfall and temperature variabilities and food crop production and rejected the null hypothesis which stated that there exist no relationship between rainfall and temperature variabilities and food crop production. This as seen in the results of food crop production as it varied with the variabilities in rainfall and temperature and also from responses from farmers. Since agriculture is the principal occupation of the Ejagham people, the promotion of production in the food crop will help in feeding the population and alleviating poverty among the rural people thus eradicating extreme hunger and poverty.

6. RECOMMENDATIONS

This study suggests the following recommendations:

The local people should get themselves more informed about weather forecasting in order to enable them know when exactly to start the planting season. This is because it will aid them to know about the prevalence of rainfall in a given season and will enable them plant at the appropriate time since two weeks delay in rainfall after planting can negatively affect plant growth.

The delegation in charge of agriculture in the area is encouraged to organise more seminars to enlighten the people on the importance planting at the appropriate time with respect to rainfall and temperature and to encourage them to use climate tolerant seeds to boost their production.

Irrigation is also encouraged in the area, especially during the dry season. From analysis of the study, only 16.7% of the population make use of irrigation. Investing in irrigation by the farmers will help boost crop production.

Encouragement for the population to engage in other sources of livelihood so as to reduce the pressure on land.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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