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Research Article

Analysis of Rainfall and Temperature Effects on Maize and Rice Productionin Akim Achiase, Ghana

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Abstract: The paper sought to analyse the effects of rainfall and temperature variability on the production of grain crops in Akim Achiase. Data from the Ghana Meteorological Agency (GMA) and the Ministry of Food and Agriculture (MoFA) were collected and analysed using graphs, chi-square, and regression. The study failed to reject the null hypotheses that no relationship exist between the average annual rainfall and temperature, and the quantities of maize and rice produced annually. The recommendations for containing the negative effects of climate variability on grain crop production include; an effective synergy between the Ghana Meteorological Agency (GMA) and the farmers.
Keywords: Rainfall, Temperature, Maize, and Rice

INTRODUCTION

Impacts of the rainfall and temperature variability are already being experienced across the globe. Change in global climatic conditions caused mainly by increase in greenhouse gases like carbon dioxide, chlorofluorocarbon, methane, etc. in the atmosphere, affects many spheres of man's life in the areas of gender, poverty, economy, governance, agriculture, food security, etc. [1]. Climate variability can be caused by both human activities and natural occurrences[2-4]. The effects are in the form of rising temperatures, unpredictable precipitation, loss of soil moisture, increased evaporation and transpiration, etc.[3,4, 5].

While rainfall and temperature variability will affect everyone, it is expected to have an uneven effect on those living in poverty in developing countries[6]. The IPPC Third Assessment Report, which assesses climate change research up to 2001 concludes that global average temperature has increased by 0.6^0C over the 20th century, and is predicted to increase by 1.4 to 5.8^oC between 1990 and 2100. Average precipitation has increased over tropical latitudes by about 2 to 3% throughout the 20th century, and on average has decreased by about 3% in the sub-tropics[7].

Yaro [1] noted that low-income rural populations that depend on traditional agricultural systems or on marginal lands are principally vulnerable to the negative effects of climate variability. Agricultural vulnerability to climate variability will lead to crop production being unsteady. Due to the fact that rural farmers do not have enough funds to engage in highly mechanized farming, like irrigation, they tend to depend more on natural precipitation which is not too predictable and dependable in tropical countries.

If the menace of higher temperatures and lower precipitation continue to impact negatively on farming activities, food production will decrease in quantity, worsening the world's food insecurity. This threat has serious health and security implications for the world.

This paper focuses on analysing the effects of rainfall and temperature variability on the production of grain crops in Akim Achiase.

Problem Statement

Agricultural production remains the main source of livelihood for rural communities in Africa, providing employment to more than 60 percent of the population and contributing about 30 percent of Gross Domestic Product [8]. In Ghana, agriculture is expected to be the most affected sector by climate variability, because it is highly dependent on climatic variables such as temperature, humidity and precipitation[4, 9].

In the last 30 years, rainfall in Ghana has decreased by 20 percent, and runoff by 30 percent[1]. Ghana have experienced about 1^oC rise in temperature over the past three decades[10]. Monthly rainfall decreased by about 2.4 percent per decade during the same period, though in the 1960s, the rainfall over Ghana was particularly high. In all these, the subsistent farmers in the Akim Achiase, predominantly food crop farmers, have acquired some perceived knowledge about their local climate and how it's variation had impacted on their farming activities.

The Birim South District is one of the notable areas in the Eastern Region of Ghana for the production of food crops like plantain, cassava, cocoyam, maize, rice, etc. However, there have been limited focus on the effect of the varying climate on the activities of local farmers. Daily observations by residents of the study area confirm varying climatic conditions in the form of perceived rising temperatures and unpredictable rainfall patterns.

A considerable number of residents in Akim Achiase are smallholder farmers, whose activities are basically rain fed. During the dry season, most of them become unemployed, worsening their poverty situation. As a result of all these conditions, most of the subsistence farmers find it difficult to obtain certain basic necessities of life. The residents, for some time now are faced with a multiplicity of socio-economic challenges because of inadequate sustainable livelihood activities in the town[11]. This has led to an increase in rural-urban migration because most people who were farmers are now fleeing to engage in illegal mining activities.

Based on the highlighted problems, this research question has been posited; how is rainfall and temperature variability affecting grain crop (maize and rice) production in the study area? The main objective of this paper is to analyse the effects of rainfall and temperature variability on the quantity of grain crops produced in Akim Achiase. The study hypothesises that there is no relationship between the average annual rainfall and temperature, and the annual quantities of maize and rice produced in Akim Achiase(Ho: μ = 0).

Profile of the study area

The study area, Akim Achiase is in the Birim South District which has an estimated area of 299.5 square kilometres, constituting about 1.6% of the total land area of the Eastern Region of Ghana. It lies between latitudes 6^{o} 1′ N and 6^{o} 20′ N, and longitudes 0^{o} 55′ W and 1^{o}10′ W. The district has a total population of 61, 786. The male population was projected at 47.6% of the 2009 projected population whilst the female population constitutes 51.4% of the projected population. It is basically rural with about 56% of population concentrated in rural settlements. The district shares borders with Birim North, Birim Central Municipality and Kwaebibirem to the north, Adansi East and Assin to the West, Asikuma Odoben Brakwa and Agona to the south, and West Akyem to the East[11].

The vegetation is mainly moist semi-deciduous characterized by tall trees with evergreen undergrowth. The climate of the district is characterized by a bi-modal rainy season with rainfall between 150cm and 200cm, reaching its maximum during the two peak periods of May – June and September – October. Average temperature ranges between 25.2 ºC minimum and 27.9 ºC maximum [12].

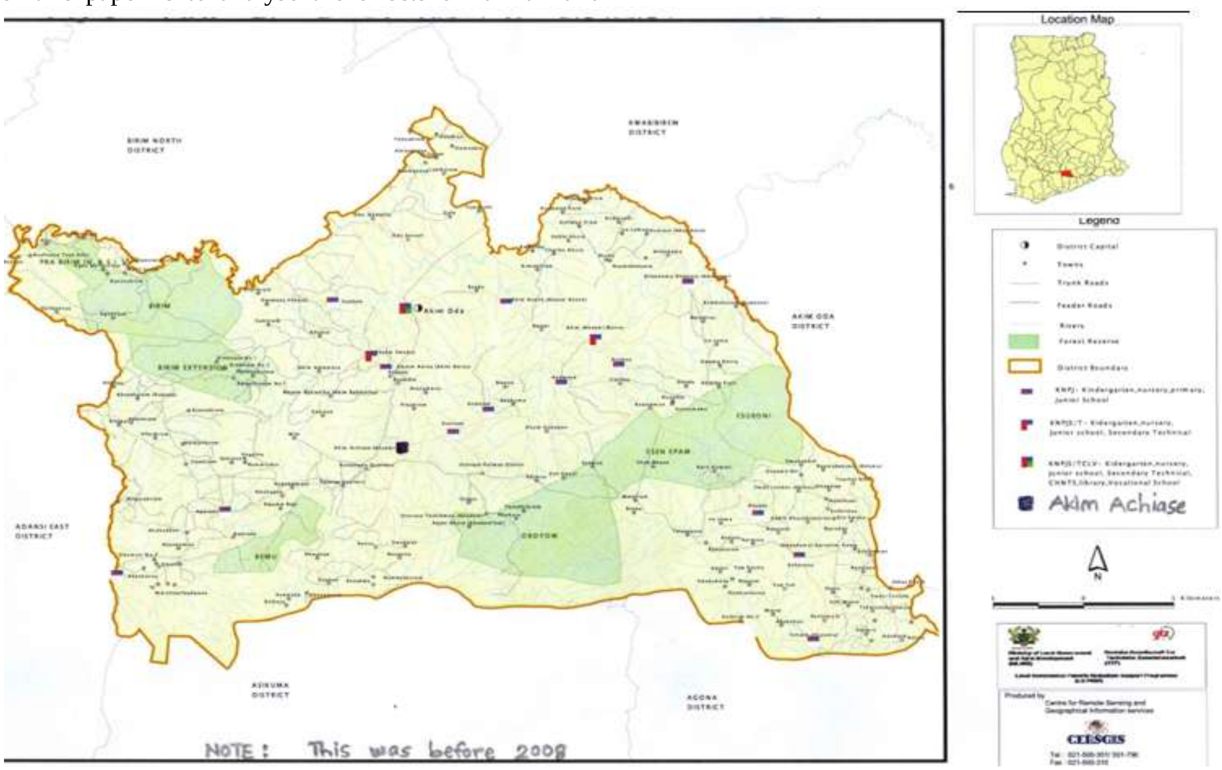


Fig-1:Map of study area in district contest
Source: Birim South District Assembly, 2014

METHODS OF DATA COLLECTION

To attain accurate information for this research study, secondary (quantitative) sources of data were collected and analysed. Resourceful information in already-existing books and literature on the topic were gathered and reviewed. Statistical data on weather elements from the Ghana Meteorological Agency (GMA) and food production quantities from the Ministry of Food and Agriculture (MoFA) were also collected and analysed. The method for collecting data included reviewing books, journals, etc., and analysing data from the GMA and the MoFA, which were related and relevant to the topic of study.

Regression, correlation, and chi-square of the Statistical Package for Service Solution (SPSS) were used to analyse the data collected. Visual presentations like graphs and charts were used to describe and explore relationships of the variables used. Also the test of hypothesis using Pearson's chi square was used to establish the relationships and strength between the dependent and independent variables under study.

RESULTS

Rainfall and Temperature Variability in Akim Achiase

Inter-annual Rainfall and Temperature Variability

Between 2000 and 2013, most of the fourteen-year rainfall data analysed (2000, 2001, 2003, 2005, 2006, 2007, 2009, and 2013) were below the towns' average of 1,750 mm. The rest of the years recorded rainfall values close to, or above the towns' average, with the year 2002, recording the highest annual rainfall amount of 1,837.8 mm. The data shows that there was high inter-annual rainfall variability, with 2000, 2003, 2005, 2007, and 2013 experiencing the highest reductions of 613, 565, 553, 582, and 567 mm respectively, below the towns' average. The nature of this variability is similar to that described by Christiaensen *et al* [12] that inter annual rainfall variability is a characteristic of sub-Sahara regions.

The lowest annual rainfall deviation from the mean were in 2002 (-88 mm) and 2010 (4 mm). Residents gave accounts of occasional flooding of major water bodies in the study area, especially in the month of April, and the severe harmattan in December, to support their claim of climate variability extremes. Figure 2 shows the annual rainfall and temperature anomalies for the various years, with respect to the town's average baselines.

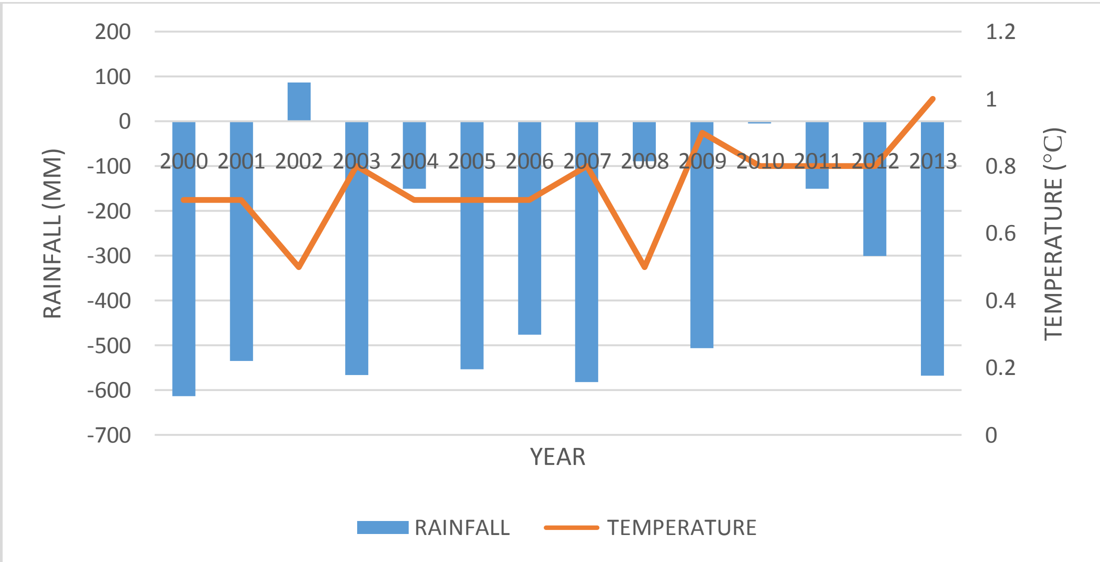


Fig. 2: Annual Rainfall and Temperature Anomalies in Akim Achiase from 2000 to 2013

NB: Rainfall and temperature baselines for the town are 1,750 mm and 26.6°C respectively

Source: Ghana Meteorological Agency (GMA, 2014)

It can be seen from Figure 2 above that the mean monthly temperature for each of the fourteen-year period depart from the normal average baseline of 26.6 °C. The average temperature for all the years in the period was higher than the town's baseline. The highest deviation was in 2013 (1°C + 26.6 °C), with the lowest being 2002 (0.5 °C + 26.6 °C) and 2008 (0.5 °C + 26.6 °C). The mean annual maximum and minimum temperature from 2000 to 2013 were 27.6 °C (2013) and 27.1 °C (2002 and 2008) respectively. The variability of temperature above the town's average confirms the World Bank finding that temperature in Africa is becoming warmer nowadays [13].

Intra-annual Variability of Rainfall

Rainfall variability in the district has not only been between years, but also within years. This is likely to have significant effects on agricultural production in the district because the amount and distribution of rainfall in a given year determines the success or failure of crop production[8]. Yields of crops will boost significantly if the rains fall at the right times, and in the right amounts.

In 2000, 2001, 2002, 2009, 2010, and 2012, the distribution of rainfall showed that the amount of rain received during the major rainy season (May—June) was higher than the minor rainy season (September—October). However, the trend was different in 2004, 2007, 2008, and 2011, where the amount of rain received in the minor season was greater than the amount received in the major season. From Figures3 (a – e) and Figure 4, it can be seen that lower amounts of rains in the major season were compensated for by higher amounts of rains during the minor seasons.

Farmers in the study area can take advantage of this trend and adopt appropriate strategies in their farming activities. They can plant drought-resistant crops during major seasons with very high amounts of rains, and also expect higher amounts of rains in the minor seasons of years with lower amounts of rains during the major season, thereby laying down measures in advance to prevent crop rots caused by stagnant water. For example, planting on ridges to drain off excess water on the land[14]. Predominantly, January was the month with the least amount of rainfall, with that of 2007 receiving no rains, as shown in Figures3 (a – e) and Figure 4.

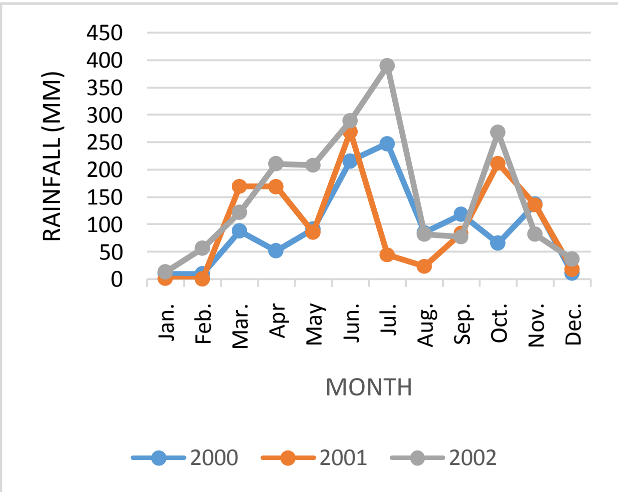


Fig. 3a

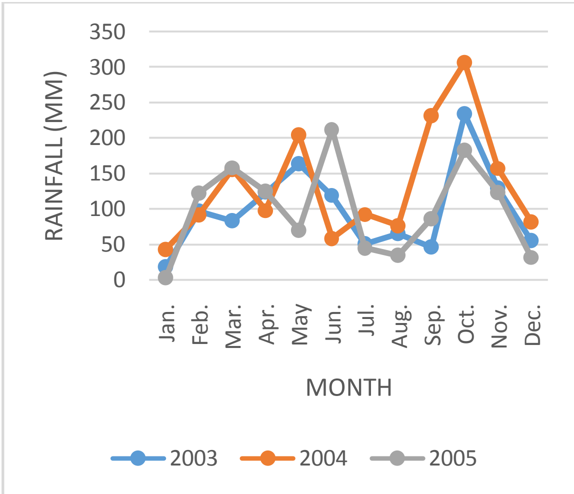


Fig. 3b

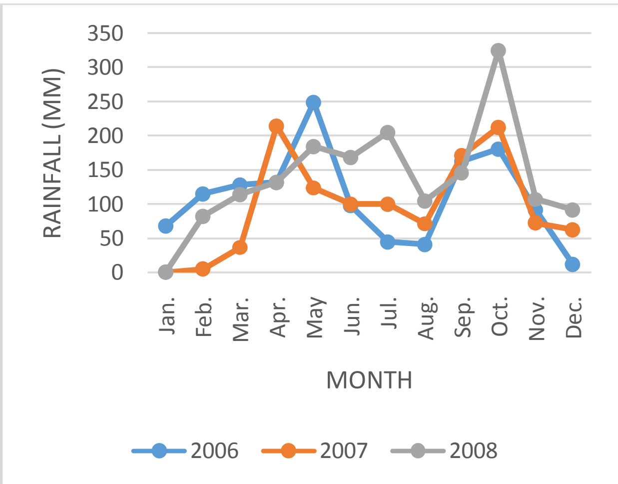


Fig. 3c

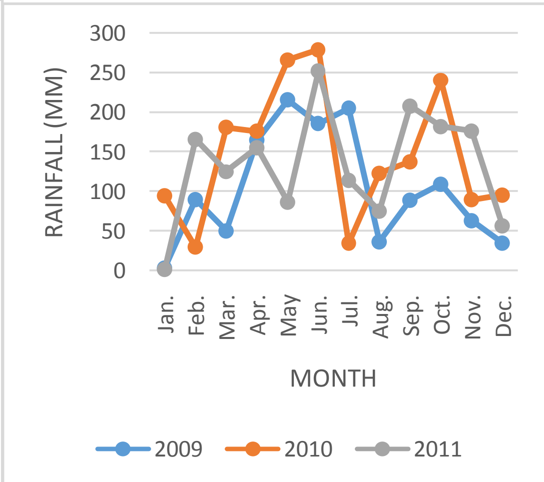


Fig. 3d

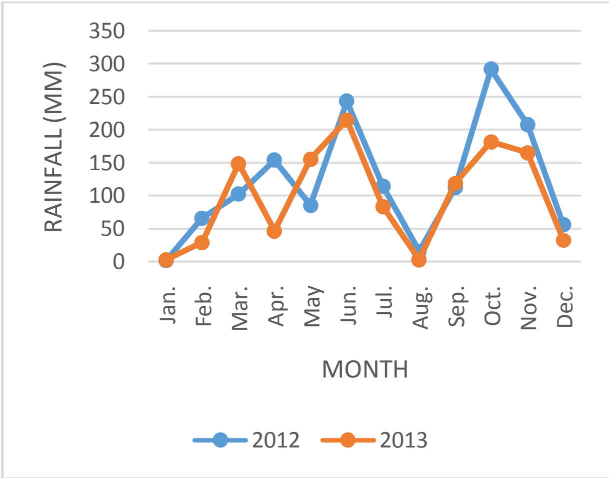


Fig. 3e

Fig. 3 (a-e): Intra-annual Rainfall Distribution from 2000 to 2013 in Akim Achiase

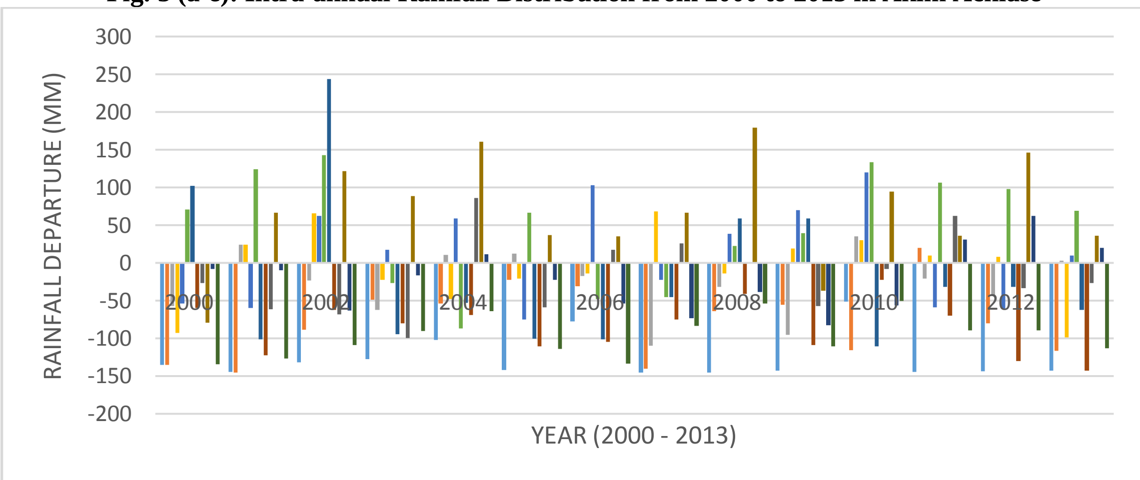


Fig. 4: Mean Monthly Rainfall Departure from Normal (2000 – 2013) in Akim Achiase

NB: *the baseline for the mean monthly rainfall for Akim Achiase was 145.8 mm* (GMA, 2014).

Source*: Ghana Meteorological Agency, 2014*

Intra-annual Variability of Temperature

It was obvious from the gathered data that temperature varied from one month to the other, especially in the major (May—June) and minor (September—October) seasons. With the exception of 2004, 2006, and 2008, all the years had the major seasons warmer than the minor seasons. The average temperatures for the major and minor seasons of 2004 and 2006 were equal, with the minor season of 2008 being warmer than the major season.

With the average rainfall for the major and minor seasons being 350 mm and 342 mm respectively, the average temperature for the major season was 27.4 °C, whilst that of the minor season was 27 °C. Also, March and April were the warmest months, with July and August being the coldest months, as shown in Figures 5 and 6 (a – e).

It can be seen from Figures 5 and 6 (a – e) that the major seasons were relatively warmer than the minor seasons, although they received comparatively much rains than the minor seasons. Receiving warm temperatures mean that the drying up of land surfaces and water bodies can be accelerated. As an adaptation strategy, farmers can plant cover crops like groundnut and cowpea during the major rainy seasons in order to conserve soil moisture [14].

The practicing of slash and burn should also be stopped, as it exposes the soil to the negative effects of the sun. Mulching should be encouraged in conserving soil moisture. Last but not the least, farmers should construct mini dams and ponds on their farms to harvest excess water to be used in January, which receives very low amounts of rains[14, 15].

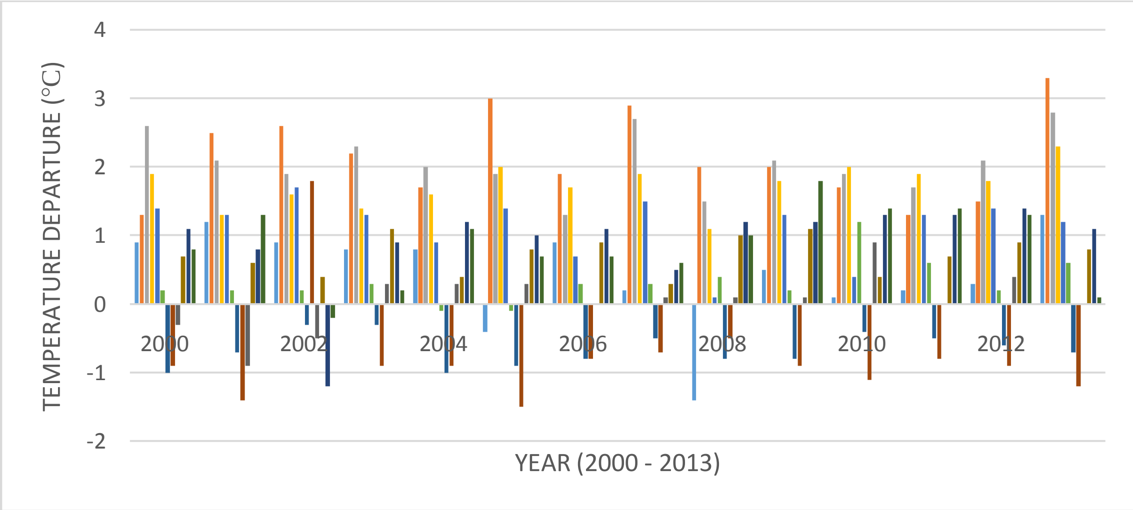


Fig. 5: Mean Monthly Temperature Departure from Normal (2000 - 2013) in Achiase

NB: the baseline for the mean monthly temperature for Akim Achiase was 26.6 °C.

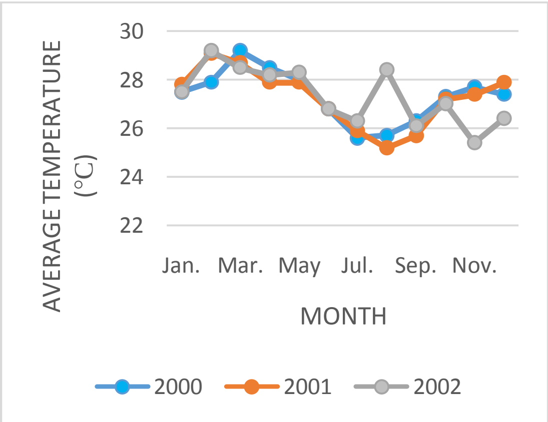


Fig. 6a

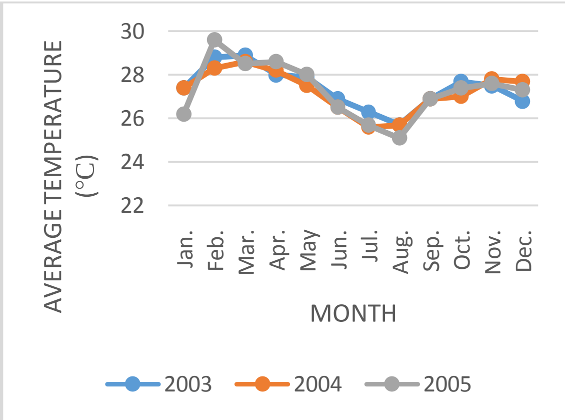


Fig. 6b

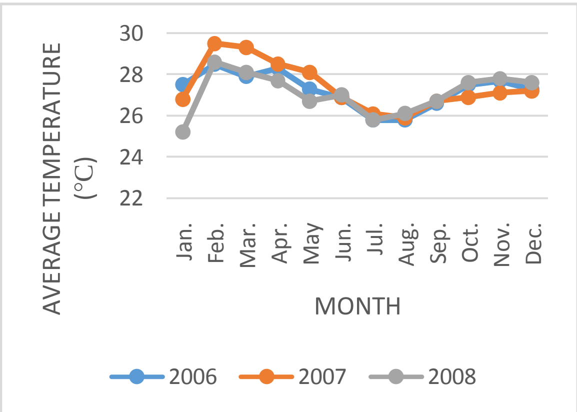


Fig. 6c

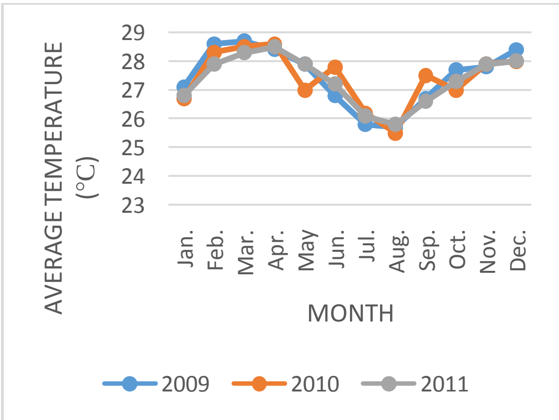


Fig. 6d

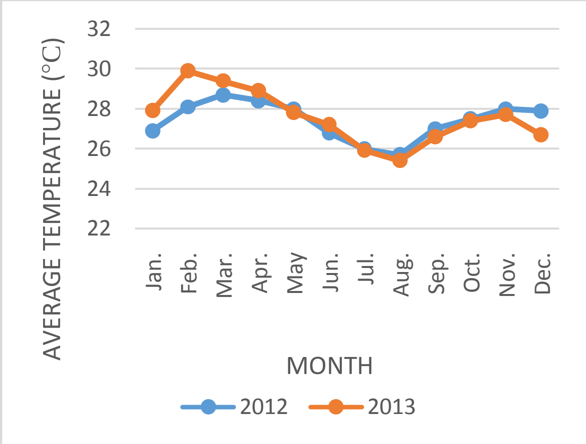


Fig. 6e

Fig. 6 (a-e): Intra-annual Temperature Distribution from 2000 to 2013 in Akim Achiase

Source: Ghana Meteorological Agency, 2014

Production Quantities of Maize and Rice in Akim Achiase (2000 – 2013)

The quantity of maize produced from 2000 to 2013 ranged from 0.50 Mt/ha (2009) to 0.58 Mt/ha (2000, 2001, and 2002). For rice, the quantity ranged from 0.54 Mt/ha (2008) to 0.69 Mt/ha (2000). Quantities produced of the two crops diminished from 2007 to 2009. Figures7a &7b shows the production trend of maize and rice.

The quantity of rice produced annually in the study area are higher than that of maize, as shown in Figures7a &7b. This is because rice producers intensify and commercialize production in order to cater for the comparably higher costs of production; for example, to pay caretakers and harvesters. The cultivation of rice is undertaken on vast expansions of land, partly because areas suitable for the cultivation of the crop exist in patches, unlike maize which can even be cultivated at one's backyard. Maize production is normally done on subsistent basis (Field survey, 2014).

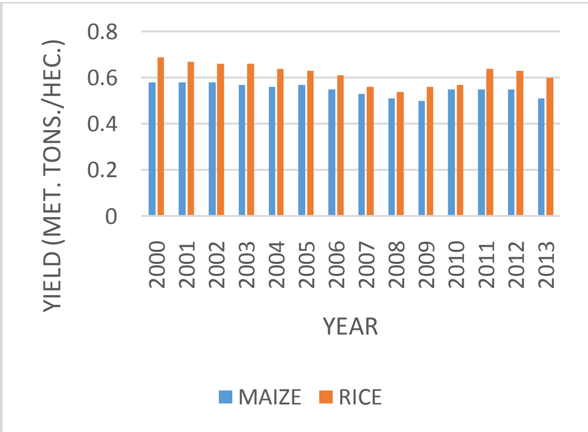


Fig. 7a

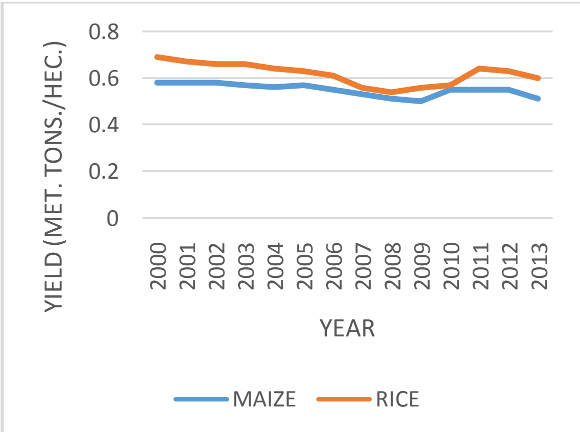


Fig. 7b

Fig. 7a &7b: Quantity of Maize and Rice Produced in Akim Achiase from 2000 – 2013

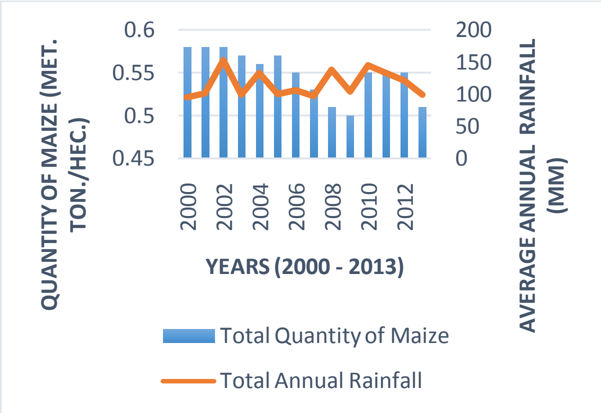
Source: Food and Agriculture Organisation (FAO, 2014)

DISCUSSION OF RESULTS

Annual Quantities of Maize Produced, and the Average Rainfall and Temperature

Studies show that rainfall and temperature are very critical factors for the growth of food crops like maize and rice [16-19]. One of the highest quantities of maize was produced in 2002 (0.58 metric tonnes/hectare), when the volume of rainfall was at its peak (153.2 mm). Also, 2009 being the year with the lowest quantity of maize produced (0.50 metric tonnes/hectare) received one of the lowest volumes of rainfall (103.8 mm) (Figures 8a & b).

As the year with the lowest quantity produced (0.50 metric tons per hectare), 2009 was one of the warmest years with an average temperature of 27.5 °C; with 2013 having the highest temperature average of 27.6 °C, but one of the lowest production quantities of 0.51 metric tons per hectare. The lowest temperature of 27.1 °C were recorded in 2002 and 2008. However they have 0.58 and 0.51 metric tons per hectares produced in the years respectively. Figures 8a & 8b further establish the trend between the two phenomena.



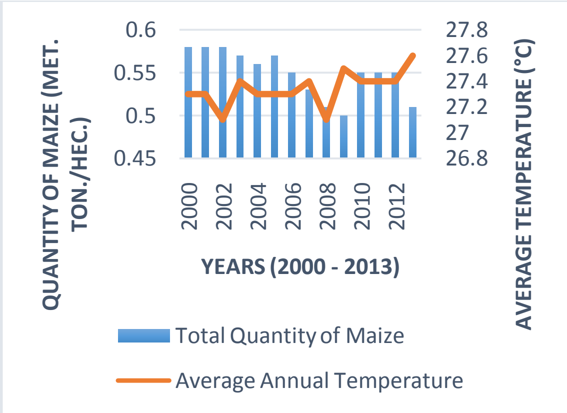


Fig. 8a **Fig. 8b**

Fig. 8a & 8b): Annual Yields of Maize, and Average Annual Rainfall and Temperature

Source: Ghana Meteorological Agency and Food and Agricultural Organization, 2014.

Table 1: Correlation, Regression, and Hypothesis Testing for the Relationship between Annual Quantity of Maize and Average Annual Rainfall

	Correlation between Maize and Rainfall	
Pearson Correlation	(General Rule : < .20 = weak, >.50 = strong)	
Test	Value	Meaning
Correlation	.044	weak correlation
Significance ($p < .05$)	.880	no relationship between variables
	Regression for Maize and Rainfall	
R Square (Rainfall should account for over 80% of maize quantity produced)		
Test	Value	Meaning
R Square	.002	rainfall accounts for 0.2% of maize produced
	Hypothesis Test for Maize and Rainfall	
Chi – Square (Significance level, p, should be less than .05)		
Test	Value	Meaning
Chi – Square	.374	no relationship between rainfall and maize prod.

Regression for the Relationship between Maize Yield and Average Rainfall

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	St. Error of the Estimate
1	.044[a]	.002	-.081	.02839

a. Predictors: (Constant), Total Annual Rainfall (mm)

Table 3: Coefficients[a]

Model	Unstandardized Coefficient		Standardized Coefficient	t	Sig.
	B	*Std. Error*	*Beta*		
1 (Constant)	.542	.045		12.039	.000
Total Annual Rainfall (mm)	5.897E-5	.000	.044	.154	.880

a. Dependent Variable: Annual Quantity of Maize Produced (Mt./hac.)

The equation for the linear regression is in the form of $Y = b_1 + b_2X$, where b_1 is the intercept, and b_2, the regression coefficient, and X is the independent variable (average annual rainfall), and Y, the dependent variable (annual quantity of maize produced).

$$\widehat{annual\ quantity\ of\ maize\ produced} = .542 + 5.897E - 5\ (average\ annual\ rainfall)$$

The constant term (intercept) is indicative of the fact that, the annual quantity of maize produced will be .542 metric tons per hectare if the average annual rainfall was 0 mm. The slope of the line (5.897E-5) also shows that an increase in the average annual rainfall by 1mm will increase the annual quantity of maize produced by 5.897E-5 (.00005897) metric tons per hectare. Thus, there is a slight positive relationship between average annual rainfall and the annual quantity of maize produced.

From Table 2, the regression reported an R squared of 0.002. This means that total annual rainfall (the independent variable) is able to account for, or explain approximately only 0.2% of the variations in the annual quantity of maize produced over the period. Indirectly, about 99.8% 0f the variations in the quantity of maize produced annually cannot be explained or accounted for by the total annual rainfall. These variations are caused by other factors that affect annual maize production, which are exogenous to the model (for example, use of improved seeds, fertilizer application, irrigation, etc.) that could have various effects on the output of annual maize per hectare.

Table 4: Correlation, Regression, and Hypothesis Testing for the Relationship between Annual Quantity of Maize and Average Annual Temperature

Correlation between Maize and Temperature		
Pearson Correlation (General Rule : < .20 = weak, >.50 = strong)		
Test	Value	Meaning
Correlation	-.411	weak correlation
Significance (p < .05)	.145	no relationship between variables
Regression for Maize and Temperature		
R Square (Temperature should account for over 80% of maize quantity produced)		
Test	Value	Meaning
R Square	.169	temperature accounts for 17% of maize prod.
Hypothesis Test for Maize and Temperature		
Chi – Square (Significance level, p, should be less than .05)		
Test	Value	Meaning
Chi – Square	.128	no relationship between temperature and maize

Regression for the Relationship between Maize Yield and Average Temperature

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.411[a]	.169	.099	.02591

a. Predictors: (Constant), Average Annual Temperature (°C)

Table 6: Coefficients[a]

Model	Unstandardized Coefficient		Standardized Coefficient	t	Sig.
	B	*Std. Error*	*Beta*		
1 (Constant)	2.833	1.464		1.936	.077
Average Annual Temperature (mm)	-.084	.054	-.411	-1.560	.145

a. Dependent Variable: Annual Quantity of Maize Produced (Met. tons./hec.)

The equation for the linear regression is in the form of $Y = b_1 + b_2X$, where b_1 is the intercept, and b_2, the regression constant. X is the independent variable (average annual rainfall), and Y, the dependent variable (annual quantity of maize produced).

$$(annual\ quantity\ of\ maize\ produced)\hat{} = 2.833 - .084\ (average\ annual\ temperature)$$

The constant term (intercept) is indicative of the fact that, the annual quantity of maize produced will be 2.833 metric tons per hectare if the average annual temperature was 0^oC. The slope of the line (-.084) also shows that an increase in the average annual temperature by 1°C will decrease the annual quantity of maize produced by .084 metric tons per hectare. Thus, there is a negative relationship between average annual temperature and the annual quantity of maize produced.

The regression from Table 5 reported an R squared of 0.169. This means that average annual temperature is able to account for or explain approximately only 17% of the variations in the annual quantity of maize produced over the period. Implicitly, about 83% of the variations in the quantity of maize produced annually cannot be accounted for by the average annual temperature. These variations are caused by other factors that affect annual maize production, which are exogenous to the model (for instance, the use of improved seeds, soil texture, drought-resistant crops, etc.) which could have effects of diverse magnitudes on the output of annual maize per hectare.

Annual Quantities of Rice Produced, and the Average Rainfall and Temperature

Rainfall and temperature are main determinant elements for the growth of rice[16-19]. Rice production in the study area has been steady, with the difference between the highest (0.69 Mt/ha.) in 2000, and the lowest (0.54 Mt/ha.) in 2008, being 0.15 Mt/ha. One of the years with the lowest average temperature of 27.1 °C (2008) had the lowest quantity of rice produced (0.54 Mt/ha). However, that was not the case for 2002, with an average temperature of 27.1 °C, producing 0.66 Mt/ha. The highest average temperature was in 2013 (27.6 °C), with 0.60 Mt/ha of rice produced (Figures9a and 9b).

With the rainfall, the highest average was recorded in 2002 (153.2 mm), which had 0.66 Mt/ha produced. Surprisingly, the year with the lowest average rainfall, 2000 (94.8 mm) had the highest quantity of rice produced (0.69 mm). This shows that food production in Ghana fluctuates from year to year due to frequent variations in the magnitude of rains during and between growing seasons. Figure 8 further shows the relationship between the quantity of rice produced and the rainfall and temperature values.

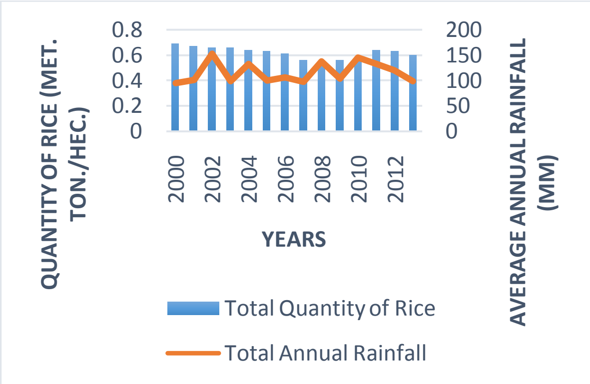


Fig. 9a

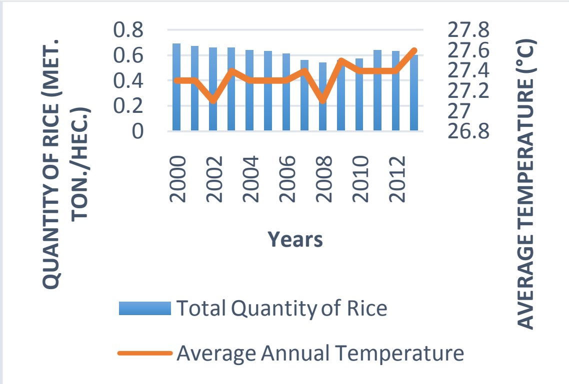


Fig. 9b

Fig. 9a &9b): Annual Yields of Rice, and Average Annual Rainfall and Temperature

Source: Food and Agriculture (FAO, 2014) and Ghana Meteorological Agency (GMA, 2014)

Table 7: Correlation, Regression, and Hypothesis Testing for the Relationship between Annual Quantity of Rice and Average Annual Rainfall

Correlation between Rice and Rainfall		
Pearson Correlation (General Rule : < .20 = weak, >.50 = strong)		
Test	Value	Meaning
Correlation	-.145	weak correlation
Significance ($p < .05$)	.620	no relationship between variables
Regression for Rice and Rainfall		
R Square (Rainfall should account for over 80% of rice quantity produced)		
Test	Value	Meaning
R Square	.021	rainfall accounts for 2.1% of rice produced
Hypothesis Test for Rice and Rainfall		
Chi – Square (Significance level, p, should be less than .05)		
Test	Value	Meaning
Chi – Square	.269	no relationship between rainfall and rice prod.

Regression for the Relationship between Rice Yield and Average Rainfall

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.145[a]	.021	-.060	.04794

a. Predictors: (Constant), Total Annual Rainfall (mm)

Table 9: Coefficients[a]

Model	Unstandardized Coefficients	Standardized Coefficients		t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.657	.076		8.633	.000
Total Annual Rainfall (mm)	.000	.001	-.145	-.509	.620

a. Dependent Variable: Annual Quantity of Rice Produced (Mt/ha)

The equation for the linear regression is of the form;

$$annual\ quanti\widehat{ty\ of}\ rice\ produced\ =\ .657+\ .000\ (average\ annual\ rainfall)$$

The constant term (intercept) is indicative of the fact that, the annual quantity of rice produced will be .657 metric tons per hectare if the average annual rainfall was 0 mm. The slope of the line (.000) also shows that an increase in the average annual rainfall by 1 mm will not cause any change, whether increase or decrease, in the annual quantity of rice produced. Thus, there is no relationship between average annual rainfall and the annual quantity of rice produced. The regression from Table 8 reported an R squared of 0.021. This means that average annual rainfall (the independent variable) is able to account for or explain approximately only 2.1% of the variations in the annual quantity of maize produced over the period. Implicitly, about 98% 0f the variations in the quantity of rice produced annually cannot be explained by the average annual rainfall. These variations are caused by other factors that affect annual rice production, which are exogenous to the model (like farming in waterlogged areas, irrigation, fertilizer application, etc.) which could have effects of diverse magnitudes on annual maize produced per hectare.

Table 9: Correlation, Regression, and Hypothesis Testing for the Relationship between Annual Quantity of Rice and Average Annual Temperature

Correlation between Rice and Temperature		
Pearson Correlation	*(General Rule : < .20 = weak, >.50 = strong)*	
Test	Value	Meaning
Correlation	-.162	weak correlation
Significance ($p < .05$)	.581	no relationship between variables
Regression for Rice and Temperature		
R Square (Temperature should account for over 80% of rice quantity produced)		
Test	Value	Meaning
R Square	.026	temperature accounts for 2.6% of rice prod.
Hypothesis Test for Rice and Temperature		
Chi – Square (Significance level, p, should be less than .05)		
Test	Value	Meaning
Chi – Square	.418	no relationship between temperature and rice

Regression for the Relationship between Rice Yield and Average Temperature

Table 10: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.162[a]	.026	-.055	.04781

a. Predictors: (Constant), Average Annual Temperature (°C)

Table 11: Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	*Std. Error*	*Beta*		
1 (Constant)	2.152	2.701		.797	.441
Average Annual Temperature (°C)	-.056	.099	-.162	-.568	.581

a. Dependent Variable: Annual Quantity of Rice Produced (Met. tons./hec.)

$$annual\ quanti\widehat{ty\ of}\ rice\ produced\ =\ 2.152-.056\ (average\ annual\ temperature)$$

The constant term (intercept) is indicative of the fact that, the annual quantity of rice produced will be 2.152 metric tons per hectare if the average annual temperature was 0 °C. The slope of the line (-.056) also shows that an increase in the average annual temperature by 1 °C will reduce the annual quantity of rice produced by .056 metric tons per hectare. Thus, there is a slight negative relationship between average annual temperature and the annual quantity of rice produced.

From Table 10, the regression reported an R squared of 0.026. This means that average annual temperature (the independent variable) is able to account for or explain approximately only 2.6% of the variations in the annual quantity of rice produced over the period. Unreservedly, about 97% of the variations in the quantity of rice produced annually cannot be accounted for by the average annual temperature. These variations are caused by other factors that affect annual rice production, which are exogenous to the model, like using improved seeds, applying fertilizers, farming in peak seasons, etc., which could have various effect on the output of annual maize produced per hectare.

Confirmation of Hypothesis

The study found out that though favorable rainfall and temperature are necessary conditions in the growth cycle of grain crops, the data sourced and analyzed do not show that a relationship exists between the two climatic elements and the quantity of grain crops produced in Akim Achiase annually.

It therefore fails to reject the null hypothesis that there is no relationship between average annual rainfall and temperature, and the quantities of grain crops (maize and rice) produced annually in Akim Achiase (**H_o: μ = 0**). Variations in the quantities of maize and rice produced in the study area may therefore be attributed to other factors which are also critical in grain crop cultivation, but may not have being considered. They include: diminishing soil fertility, overusing of chemical fertilizers, thereby yielding adverse effects, side effects of agro-chemicals (for example pesticides and weedicides), increased activities of pests, salinization of soils caused by excessive irrigation, wrong breeds of crops grown in some particular seasons, etc.

Conclusion and Policy Implication

Grain crop production is always vulnerable to unfavourable weather events and climate conditions. Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are important factors which play a significant role in agricultural productivity. Notwithstanding these, the finding by this study shows that rainfall and temperature are not the only determinants of grain crop survival, thus higher yields. The other factors like the fertility of the soils, farming methods, etc., must also be given equal attention, when analysing the relationships between climatic variables and food crop output.

The policy implication for this study is that; the Government of Ghana (GoG), through the Ministry of Food and Agriculture (MoFA), should note that it is not only the natural elements of climate (rainfall and temperature)that affect the quantities of grain crops produced. They should therefore not channel all their efforts on such areas, but also on other aspects like farm inputs and agro-chemicals the farmers use in their farms.

The Birim South district assembly should therefore assist farmers in obtaining farm inputs like fertilizers, irrigation equipment, weedicides, etc., because most of the farmers do not have enough funds to purchase them. Also, farmers' education through symposiums should be a priority, in order to exchange knowledge about the climate.

Recommendations

The Birim South District Assembly should respond to climate change impacts on agriculture by investing in research into drought, early maturing, and disease-resistant crop varieties, soil conservation measures, irrigation and water harvesting development, expanding fertilizer use, education, etc.

The Birim South District branch of the Ghana Meteorological Agency should be resourced to establish local meteorological stations, monitor and publish climate data, and also develop climate forecasts in order to put more efforts into providing farmers with accurate weather forecasts.

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