Seasonal Variations in Climatic Elements and Cocoa Production: Evidence from Central Region, Ghana

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Abstract

Undoubtedly, cocoa production is the backbone of Ghana's economy. In spite of the recent transition to an industry and service sector-led economy, agriculture still plays a fundamental role in Ghana's economic activities. The study aimed at examining the seasonal variations in climatic elements and cocoa production in the Central Region of Ghana. The Microsoft Excel Function of Linear Trend as well as line charts were used to analyze the trend of seasonal variations in climatic elements in the Region. The Line chart, trend line, trend equation and the degree of variation within the excel function were used to determine the nature and direction of the trend of the quarterly rainfall, temperature (maximum and minimum), relative humidity and seasonal cocoa output. Again, the inter-annual anomalies for the time series data (temperature, relative humidity, rainfall and cocoa output) were calculated using the Microsoft Excel software to assess the year to year variability of the climatic variables over a five-year period (2010 to 2014) in the two Districts in the Central Region. This data was taken from the Ghana metrological agency and the produce Buying Company Ghana (PBC) in central region, Ghana.

It is evident from the study that, there are seasonal variations in climatic elements in the study area. Also, seasonal variations in Temperature, precipitation and relative humidity play a considerable role in cocoa production in Central Region, Ghana. It was established that extreme temperature adversely affected cocoa output in the sub-region. An important implication of this study is the recognition that seasonal variations in climatic elements' effects are the determinants of cocoa output and not coincident effects. This finds support from the agronomic point of view considering the gestation period of the cocoa crop.

Keywords: seasonal variations in climatic elements, Central Region, Cocoa output, relative humidity, temperature, rain fall.

1.0 Introduction

In spite of the recent transition to an industry and service sector-led economy, agriculture still plays a fundamental role in Ghana's economic activities. Agriculture accounts for approximately 30 percent of the country's Gross Domestic Product (GDP), and employs almost 50 percent of the labour force (Tunde, 2011). The cocoa industry in Ghana employs over 800,000 smallholder farm families, share croppers, and their dependants (Asamoah &Baah, 2003). The number of cocoa farm owners is estimated at 350,000 people. For smallholder cocoa farmers, cocoa contributes to about 70-100% of their annual household incomes (Asamoah &Baah, 2003).

Notwithstanding the tremendous contribution of cocoa to the rural and national economy, the crop's production faces several challenges that do not only limit its potentials, but also raises concerns about future sustainability and competitiveness of Ghana's cocoa farmers in an ever changing global economy. One of the two factors affecting cocoa yield is climate, the other is soil erosion (Sarker, 2012). Hence, to improve the production of cocoa, there is the need to understand weather conditions of the producing areas.Cocoa contributes to the livelihood of cocoa farmers in Ghana, and to the macro economy of the country as a whole.

For example weather and climate have, over the years, greatly affected the production of cocoa, the major cash crop in the Central Region of Ghana. Central Region ranks among the highest cocoa producing areas in Ghana. Cocoa farmers in the region have, over the years, sought to grapple with the conventional pre and post-harvest challenges such as shortage of technical expertise, transportation problems, marketing and other infrastructural problems, among others, facing the cocoa industry in Ghana. They are also faced with a more precarious situation of changes in the climatic elements from season to season, which affect production. Variations in the three climatic parameters, (rainfall, temperature and humidity), affect the sprouting and growth of the cacao tree, and the production of cocoa pods. Ghana has already experienced an increase in mean annual temperature of 1°C per decade since 1960 (Government of Ghana, 2011). Monthly rainfall decreased about 2.4 percent per decade during the same period, though in the 1960s, rainfall over the country was particularly high (Government of Ghana, 2011).

The alternating climatic conditions have increased the frequency and magnitude of pests and diseases affecting the cacao tree. The (observed) variabilities in temperature and rainfall between 1960 and 2010 for example have led to variations and to the decline in the crops yields per hectare. For instance according to (Owusu & Waylen ,2009), Ghana experienced very hot weather conditions in 1976 and in 1983 to 1984 during which periods there were drastic reductions in cocoa output from 62,762 metric tonnes in 1971/72 to 13,818 metric tonnes in 1983/84 in the Central Region of Ghana (COCOBOD, 2010). National cocoa purchases also decreased by 13% from 1,011,880 metric tonnes in 2010/11 to 879,240 metric tonnes in the 2011/12 farming years due to unfavourable weather conditions (COCOBOD, 2011).

Unfortunately strategies adopted by the indigenous farming population too have been largely inadequate. This problem has been compounded by the fact that cacao that is growing requires much investment, especially in time. The absence of climatic monitoring and communication systems in Central Region, and the shortage of technical assistance, coupled with high illiteracy among the majority of cocoa farmers, work against the possibilities of enhancing adaptation strategies during the changing climate condition.

Since agriculture especially cocoa production has been the backbone of the Ghanaian economy, it is necessary to design ways for sustaining the country's agriculture. Ghana stands the risk of losing its position as the second world leading producer of cocoa if the current trends in the climatic elements persist. However studies on the impact of variations in climatic elements on the countries arable crops are many, but those on cocoa yield, are few in the literature. This study tries to find the extent to which variations in the climatic elements especially in temperature, rainfall and humidity have affected cocoa production in two cocoa Districts (Cape Coast and Dunkwa-on-Offin) in Central Region.

2.0 Literature Review

Climate trends and climatic extreme indices derived from empirical, observed data indicate that global average surface temperatures have been increasing since the mid-19th century with the greatest rate of change observable since the mid-1970s (IPCC, 2014). This may be attributed to the continuous generation of greenhouse gases through human activities. The recent report of the IPCC reiterates the fact that, anthropogenic factors remain a major cause of recent global warming. Due to the concentration of the greenhouse gases in the atmosphere, temperature continues to rise through the greenhouse effect and this has potentially contributed to the alteration of the rainfall pattern across the globe. Recent climatological studies have shown an increase in global surface air temperature by 0.76°C from 1850 to 2005 (Bakri &Abou-Shleel, 2013). The study reveals the extent to which global temperatures have increased. However, it fails to add to the discourse about the causes of the phenomenon which is fundamentally critical in analyzing issues of seasonal variations in climatic elements.

A research carried out by (Poulter et al. 2013) in the inner Asia which includes the semi-arid regions of northern China, Mongolia, and parts of southern Russia reveals an increase in mean annual air temperature. A similar research conducted by (Cinco, Guzman, Hilario & Wilson, 2014) on temperature anomalies in the Philippines for the period 1951–2010 against the baseline period of 1961–1990 demonstrates an overall increasing trend with values becoming positive in 1977 and „peaking" in 1998 with a +1.0 °C anomaly.

From 1996 to 2010, the end of the observed period, positive anomalies were consistently greater than 0.5 °C with 2005 and 2006 marking the peak warm years of the first decade of the 21st century. The temperature anomaly as revealed in the research gives evidence which is consistent with seasonal variations in climatic elements. Further studies in Asia have also shown an increase in mean annual temperature. For instance, according to a study by Cinco et al., (2014) the mean annual temperature (MAT) in the whole Yangtze basin of China over the period 1955–2011 was 14.0oC ranging from 13.4oC to 14.9oC. The MAT increased from 12.7oC in the upper section of the catchment to 16.0oC in the lower basin. The study shows a variation in the increase in the annual mean temperature of the upper and lower basins. (Boyles & Raman 2003) cited in Sayemuzzaman, et al., (2014), studied temperature and precipitation trends on seasonal and annual time scales in North Carolina, United States between 1949 and 1998. The study analysed, using the linear time series slopes to investigate the spatial and temporal trends of precipitation. The study in the final analysis revealed a warmer temperature trend during the 1990s and the warmest being 1950. It can be noted from the analysis that, even though temperature increased within the stipulated duration, the early years experienced much more increase than the latter years and hence, temperature increased at a decreasing rate.

On the contrary, (Kruger & Shongwe, 2004) argue that, there has not been any gradual increase regarding the annual mean temperature trends. According to them, the average mean temperature of two periods, 1960 to 1990 and 1960 to 2003 did not show much difference in terms of the trends of the two periods. Their conclusion was that, between the periods of 1960 to 1990, the average mean temperature was 18.18oC with a trend of 0.11°C whereas the period 1991 to 2003 had an average mean temperature of 18.48°C and a trend of 0.09°C per decade. Therefore, their argument was that the trend for the latter period was slightly lower than that of the former which meant that temperatures have not been increasing as earlier argued.

Based on the trends of the seasonal variations in climatic elements over the past decade, the average temperature in Ghana from the period 2010 to 2050 is predicted to range between 34°C (Forest region, Ghana wet scenario) and 41°C (Northern Savannah, Ghana Dry scenario) (World Bank, 2009). This evidence shows that the climatic trend in most part of the world especially, Sub-Sahara Africa keeps on drifting to the negative with its effects on the environment and agricultural production. It is therefore important that farmers within the Sub-region be given the needed empowerment to be able to implement effective adaptation strategies to help respond or reduce the impact of the seasonal variations in climatic elements.

Similarly, a significant linear increase in mean annual air temperature occurred between 1960 and 2001 along the coast of Ghana of about 0.9°C; the maximum and minimum temperatures increased by 2.5 and 2.2°C, respectively, during this time sea-surface temperatures showed a slight but non-significant increase during this period (Dontwi, Dontwi & Buabeng, 2008).

Moreover, it is further projected that, countries are expected to experience an increase in average temperature overall by 1°C by 2030 and by 1.4°C by 2050 (IPCC, 2001). In a similar direction, eco-climatic zone projection of mean annual temperature in most part of Ghana is projected to increase significantly within 30 years interval from 1920, 1950 and 1980 with a corresponding temperature increase of 0.6, 2.0 and 3.9-4.0oC (Minia, 2008). These projections of climatic trends therefore make it imperative for more research to be conducted to help ameliorate the problem.

In the case of Ghana, research has revealed that the annual rainfall in the country is highly variable on inter-annual and inter-decadal timescales, making identification of long-term trends difficult. However, in the 1960s, rainfall in Ghana was particularly high and decreased to particularly low levels in the late 1970s and early 1980s. This caused an overall country-wide decreasing trend in the period 1960 to 2006 of an average 2.3mm/month (2.4 percent)/decade (McSweeney, New &Lazcano, 2008). Additionally, another study conducted by Dontwi et al., (2008) with specific reference to the Coastal areas in Ghana shows a significant linear decrease trend from 1961 to 2000 (decrease of about 1000 mm) with a marked cycling of high and low rainfall years with an apparent six-year lag. Comparison of the mean annual rainfall differences between 1951-1970 and 1981-2000 at meteorological stations across Ghana also indicate less rainfall (Owusu &Waylen, 2009 cited in Stanturf, Warren, Charnley, Polasky, Goodrick, Armah, & Nyarko, 2011). The reduction of rainfall in Ghana between the periods of 1981-2000 may have partly stemmed from the severe drought condition experienced in 1983, which culminated in hunger and famine in the country with most people travelling to other parts of the world. The reduction in rainfall did not only affect the flora but it also affected fauna and aquatic species. Again, the reduction in rainfall goes a long way to affect plant growth. There is therefore the fear that, the reduction in rainfall among countries in Sub Saharan Africa may continue to worsen, the food security situation since most of the crops cultivated on the continent are rain-fed.

Cocoa is highly sensitive to changes in climate, particularly to temperature due to its effects on evapo-transpiration (Anim-Kwapong& Frimpong, 2005) and is known to thrive well with minimal but sustained water availability throughout the year (Obatolu& Esan, 1999). Yearly variation in the yield of cocoa is affected more by rainfall than any other climatic factors. Cocoa prefers calm conditions, for even persistent moderate wind can cause severe damage to yield. Thus being a selective plant, cocoa reacts badly to any incidence of extreme weather (William & Stan, 2003). International Cocoa Organization (2005) described extreme weather to include weather phenomena that are at the extreme of the historical distribution and observed that temperature and rainfall are important factors that impacts on optimum yield. Variations in rainfall and temperature could alter stages and rates of development of cocoa pests and pathogens, modify host resistance and result in changes in the physiology of host – pathogen/pest interaction. The most likely consequences are shifts in the geographical distribution of host and pathogen/pests, altered crop yields and crop loses. Annual rainfall in excess of 2,500 mm may lead to a higher incidence of fungus diseases, the most common known as phytophtorapod rot which causes the black pod disease, and the cocoa swollen shoot virus (ICCO, 2000; William & Stan, 2003).

According to the ICCO (2005), an increase in maximum temperature of the warmest month and in the annual temperature range will impact negatively in the cocoa-growing regions by 2050. Based on the projections of CIAT for 2030, suitable areas for cocoa production will start shifting, and this will mainly affect the southern areas of the Brong-Ahafo, and Western Regions in Ghana. Furthermore, conditions similar to the current climates of high temperature will remain only in the areas between Central, Ashanti and Eastern Regions.

However, the remaining cocoa growing climate areas will still be suitable for the production of cocoa. CIAT (n.d) predict that “by 2050, cocoa production will become concentrated in two areas in Ghana, between the Central and Ashanti Regions, and in the mountain ranges of the Kwahu Plateau between the Eastern and Ashanti Regions.” (Environmental Protection Agency, 2008) using a General Circulation Model (GCM) and Simple Climate Model (SCM) has also projected a decline in rainfall for the years 2020, 2050 and 2080. With this decline in rainfall it is expected that cocoa output will decline from the year 2020 to 2080.

3.0 Research Design

3.1 Conceptual Framework

There have been myriads of theories in an attempt to explain food security in the context of seasonal variations in climatic elements impact and adaptation strategies in developing countries. Among these theories are the modernization theory and the structuralism which were employed by most developing countries to help sustain food production and to reduce poverty among developing countries through agricultural modernization and industrialization. The weaknesses of these theories made them inadequate in providing a better explanation for ensuring food security among third world economies. In pursuant to providing a better explanation of how to sustain food production through adaptive mechanisms in response to the impact of seasonal variations in climatic elements, the Action Theory of Adaptation (ATA) was adopted.

The ATA explains the initiative and exercise of adaptation strategies (actions) by various key actors and stakeholders (farmers and institutions) as a response mechanism to reduce the impact of seasonal variations in climatic elements (Eisenack & Stecker, 2011). According to the theory, actions in the form of adaptation strategies are employed to cope with climate variability impacts. The IPCC (2014) reiterates the need to reduce and manage the impacts and risks of climate change through adaptation and mitigation. The actions require actors and an intention to unleash the needed actions through the actors.

The farmer must first perceive that there are seasonal variations in climatic elements. The use of adaptation requires the provision of resources as a means to achieve the intended ends. The ATA is strongly built around some key concepts namely stimuli, exposure unit, operator and receptor. The stimuli concept refers to the change of biophysical variables (e.g. meteorological variables) which are triggered by climate change (Eisenack & Stecker, 2011). The stimuli therefore cause some changes to biophysical variables such as climate variables (e.g. temperature and rainfall) as a result of the impact of the climatic variations. The stimuli become relevant for adaptation when they are able to influence the exposure units.

The exposure unit refers to the non-human systems that depend on climatic conditions, and are therefore exposed to the stimuli (Eisenack & Stecker, 2011). The exposure unit may be extended to cover social, technical and other systems that may be studied in an adaptation study. It is important to note that the combination of the stimuli and the exposure unit constitute the impact. Receptors are the actors or systems that are addressed by the purpose of an adaptation. The receptors are the target of the adaptation or the social systems that ultimately exercise the adaptation strategies. The receptors can also be both biophysical entities (e.g. the crops of a famer) and social systems (e.g. the farmer household), depending on the objective of analysis (Eisenack & Stecker, 2011). Operators are the actors or institutions who wield the power, knowledge and means to exercise or initiate the adaptation strategies (Eisenack & Stecker, 2011). Operators are therefore the organisations, institutions or other social systems that facilitate the adaptation strategies of the receptors. For instance, operators can be public or private institution with the knowledge and means to initiate adaptation. The receptors and the operators are actors who initiate and exercise the needed actions in responding to the impact of seasonal variations in climatic elements.

3.2 Profile of the Study Area, Data Sources and Processing

The Central Region shares common boundaries with Western region on the west, Ashanti and Eastern regions on the north, the Greater Accra Region on the East and on the south by the Gulf of Guinea. Specifically the study area represents two cocoa Districts from the Region. The cocoa Region is different from the administrative region. The coca Central Region has some communities in the Western Region included especially communities in the WassaMporhor District. The bulk of Ghana’s cocoa is produced in the moist evergreen and moist semi-deciduous forest areas, thus for the purpose of assessing potential variations in climatic elements’ effect on cocoa production in the Central Region of Ghana, two areas (cocoa districts) representative of these forest types are chosen for the study. These are: 1. Dunkwa–on-Offin (Moist evergreen- Western North region) 2. Cape coast in (Moist evergreen- central region). Ghana cocoa can only be profitably grown in the tropical rain forest belt. The tropical rain forest of Ghana is divided into five major forest types namely: Wet evergreen, Upland evergreen, Moist evergreen, Moist Semi- deciduous (North –West and South-East subtypes) and Dry semi-deciduous (Fire Zone, inner Zone and marginal subtypes) (Hall & Swaine, 1981).

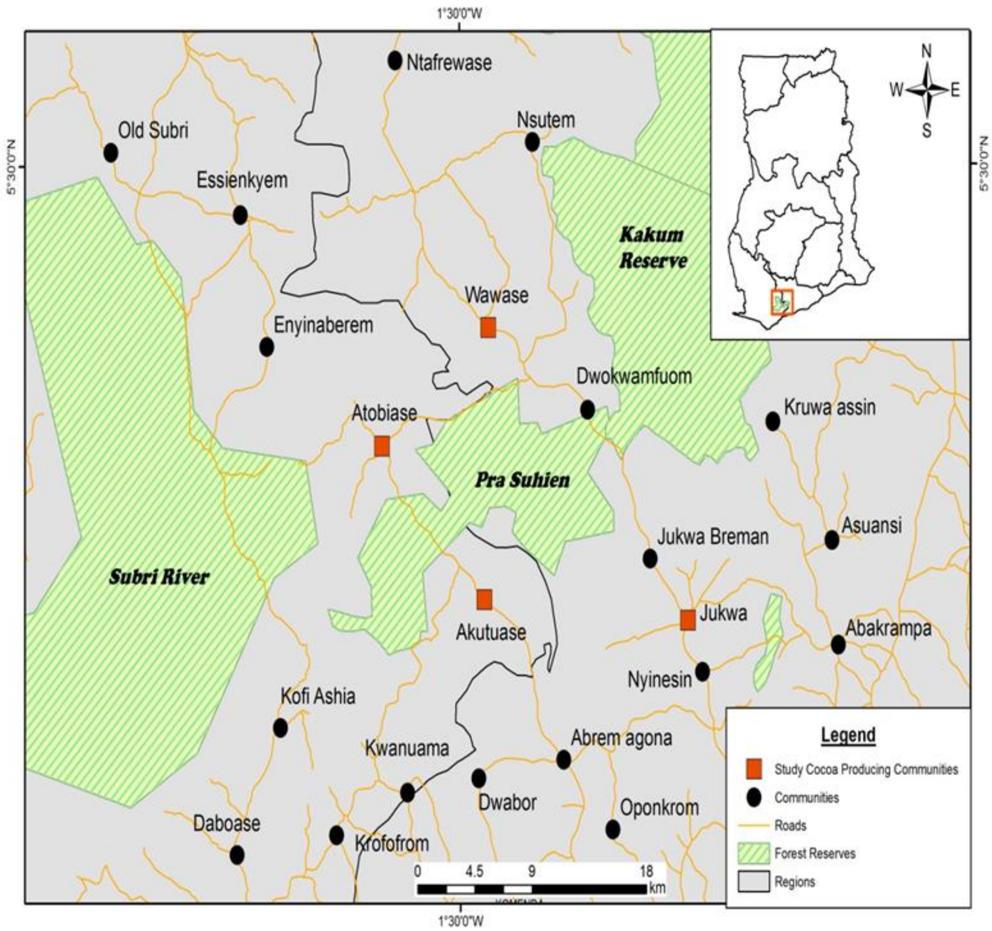

Figure 1: Map of the Study area.

Both quantitative and qualitative data were gathered from respondents. Data were from both primary and secondary sources. Primary data were collected from key informants who were all cocoa farmers, Agricultural Extension Officers and Field Officers of the Produce Buying Companies (PBC), while secondary data were obtained from the Central Regional Meteorological Agency, books, and Ghana Cocoa Board.

The quantitative data were analyzed using both descriptive and inferential statistics with the help of the IBM SPSS Statistics Software Version 17 and the Microsoft Excel Software. Analytical tools such as frequency, percentages, Cross-tabulation, Chi-square and trend equations and graphs were used to analyze the quantitative data. The three tier analytical framework of transcription, classification and interconnecting were used to analyze the qualitative data. Quarterly rainfall, temperature (maximum and minimum), relative humidity and seasonal cocoa output. Again, the inter-annual anomalies for the time series data (temperature, relative humidity, rainfall and cocoa output) were calculated using the Microsoft Excel software to assess the year to year variability of the climatic variables over a five year period (2010 to 2014) in the two Districts in the Central Region.

4.0 Empirical Results

4.1 Variations in the Climatic Elements in Dunkwa-on-Offin District

Figure 2 shows that the maximum temperature has varied over the five year period (2010-2014) in the Dunkwa-on- Offin cocoa District. Maximum temperature decreased sharply from 2010 to 2011 and then rose sharply in 2012 and 2013 which recorded the highest ever within the five year period under study. Again, there was a sharp decrease in maximum temperature from 2013 to 2014 which recorded about 32.1oc. It is observed from the time series data that 2011 and 2013 recorded the lowest and the highest maximum temperature of 31.0oC and 32.2oC respectively.

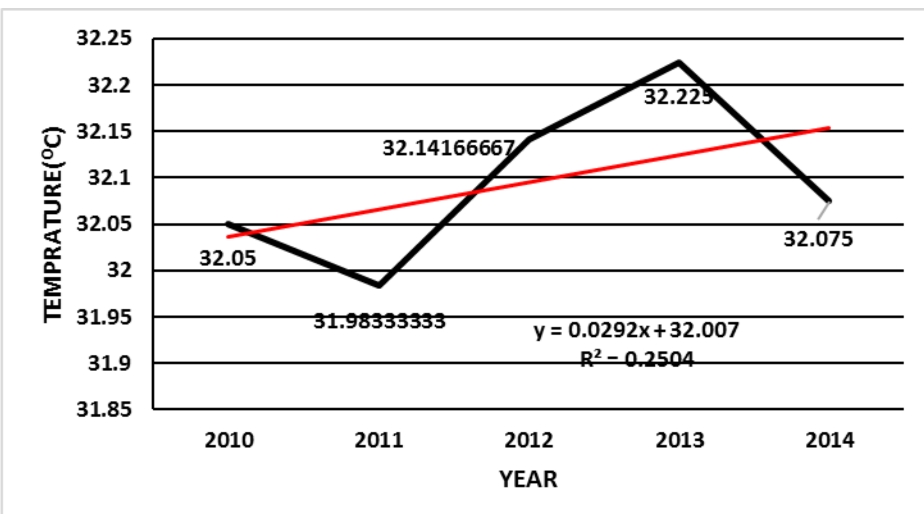

Figure 2: Variations in the mean maximum temperature for Dunkwa-on- Offin (2010- 2014)

Source: Field Data, 2015

This supports the findings of International Cocoa Organization (ICCO), (2005) who asserts that cocoa plants respond well to relatively high temperatures, with a maximum annual average of 30- 320c. The Dunkwa – on- Offin cocoa district support the production of cocoa because of the favorable climatic conditions. The trend equation and the trend line of the mean maximum temperature generally shows an increasing trend (0.0292x) which means that the average maximum temperature over the years (2010-2014) has been increasing. The degree of variation (R2 =0.2904) shows the variability in maximum temperature in the area. The reason for the rise or increase in maximum temperature in the district may be partly due to the extent of bad farming practices (e.g. slash and burn) coupled with deforestation that characterizes farming activities in the area. The reality about the causes of the increasing temperature trend in the district was reinforced by the assertion made by one of the women cocoa farmer who retorted that:

"The seasonal variations in climatic elements are as a result of God's plan to signifying the end time" (In-depth interview, 2014).

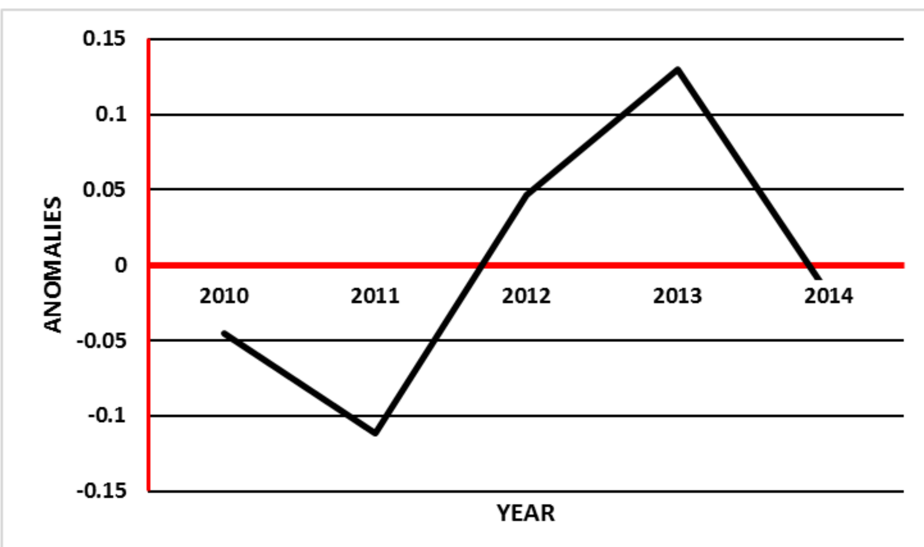

Figure 3: Anomalies in mean maximum temperature for Dunkwa-on- Offin (2010- 2014)

Source: Field Data, 2015

It is evident from the inter-annual variability graph that there are anomalies in the maximum temperature as observed in the time series data with a greater number of the mean values being positive. These are indications that the district is becoming warmer. This is consistent with the study of (Hansen, Sato & Ruedy, 2012) who assert that more warming conditions would be experienced in the 21st century than the preceding decades. Similarly, majority of the farmers during the focus group discussion also acknowledged the increasing trend in temperature over the years. This may be as a result of increasing intensity and duration of sunshine and rainfall variability in the African continent as observed by several researchers (Mendelsohn & Dinner, 1999; Deressa & Hassan, 2009; Ward, Floex & Flore-Lagunes, 2011).

The implication for the rise in temperature in the district is the fact that, this will increase the rate of evaporation and cause a reduction in soil moisture. When evaporation increases, the result is that the amount of soil moisture lost through evaporation will also increase thereby leaving little or no moisture to support plant growth. The anticipation is that the area will continue to get warmer to the detriment of plant and animal life which will inexorably affect productivity of cocoa. This anomaly could potentially lead to a reduction in cocoa yield in the district. Figure 4 portrays the minimum temperature trend in the district over the period, 2010 to 2014. From Figure 6, it is also apparent that the minimum temperature shows some variations over the past 5 years (2010-2014) in the district. The graph shows a decrease in minimum temperature from 2010 to 2011. There was a slight rise in 2012 and 2013 before showing some level of decrease in 2014.

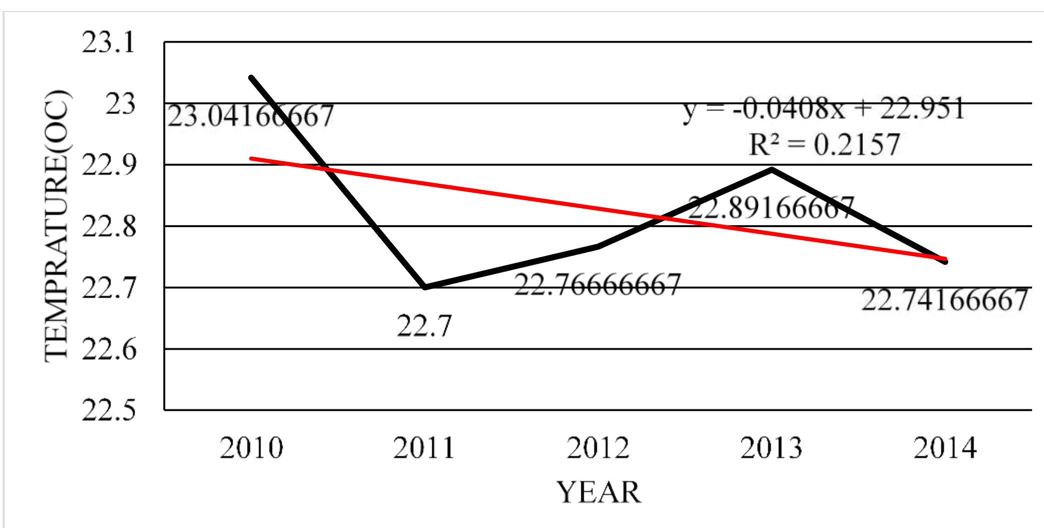

Figure 4: Variations in the mean minimum temperature for Dunkwa-on- Offin (2010- 2014)

Source: Field Data, 2015

The trend equation and the trend line of the mean minimum temperature generally shows a decreasing trend (0.0408x) which means that the average minimum temperature over the years (2010- 2014) has been rising. The degree of variation ($R2 = 0.2157$) shows that the variability in minimum temperature in the area. The estimated anomalies of the inter-annual minimum temperature variations showed the amount of minimum temperatures that have varied from year to year (See Figure 5). It is evident from the inter-annual variability graph that there are anomalies in the minimum temperature as observed in the time series data with most of the mean values being negative. This indicates that there is an overall variability in the minimum temperatures in the district which can influence cocoa production.

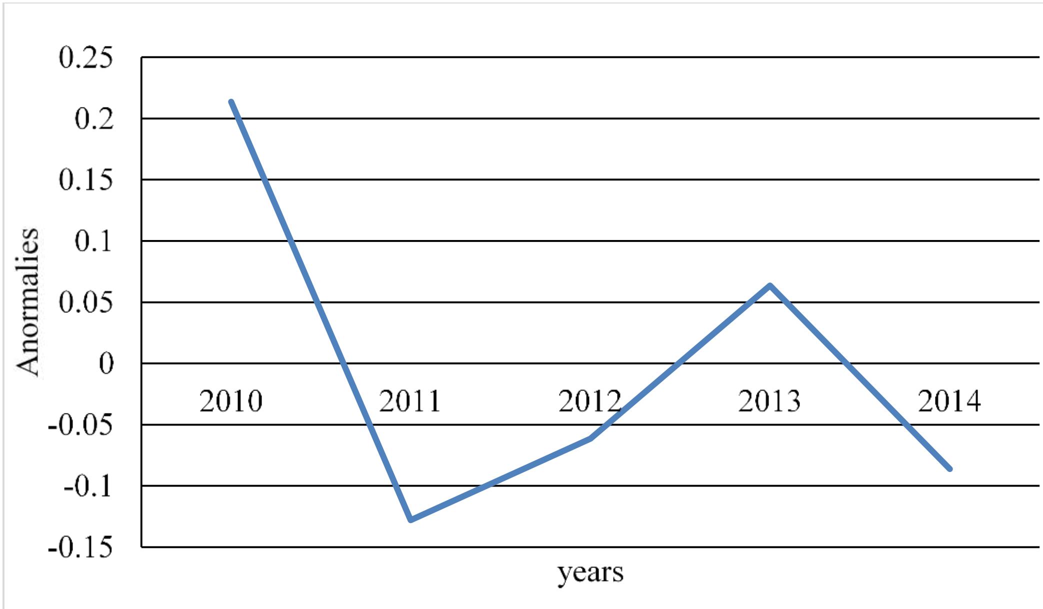

Figure 5: Anomalies in mean minimum temperature for Dunkwa-on- Offin (2010- 2014)

Source: Field Data, 2015

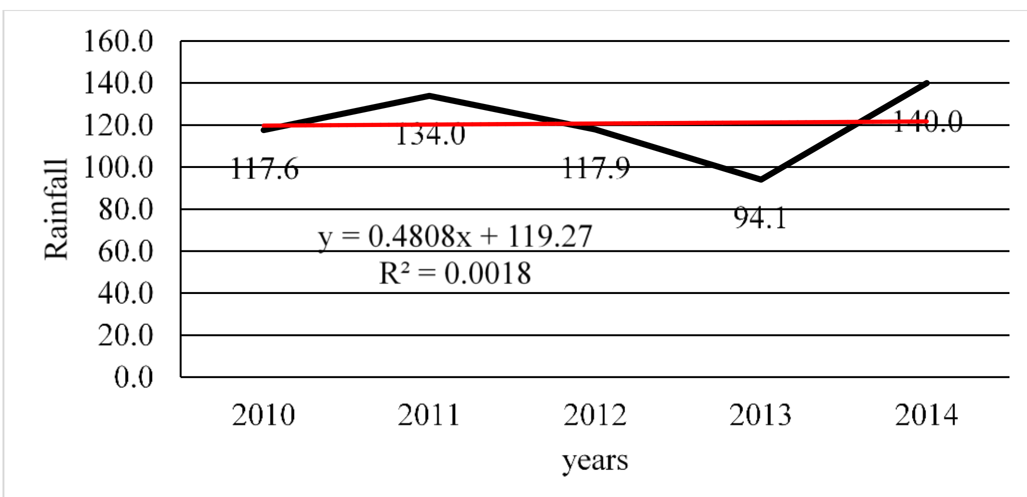

Figure 6: Variations in mean annual Rainfall for DunkwaOffin (2010- 2014)

Source: Field Data, 2015

From Figure: 6, above mean rainfall has been high over the five year period with highest been 140mm and the lowest been 94.1mm in 2013. From the figure above it can be observed that the degree of variability has been relatively stable. This is a good sign for farmers since their prediction on yearly output will be high.

Figure 7: Anomalies in mean annual Rainfall for Dunkwa-on- Offin (2010- 2014)

Source: Field Data, 2015

The estimated anomaly of the inter-annual rainfall variation shows the amount of rainfall that has varied from year to year (See Figure 7). It is evident from the trend anomalies that rainfall as observed in recent year (2014) recorded a relatively higher anomaly as compared to the earlier year (2013) which showed high negative mean value.

4.2 Variations in the Climatic Elements in Cape Coast District

From Figure 8, it is obvious that the maximum temperature has varied over the past five years (2010-2014) in the Cape Coast cocoa District. Maximum temperature in the district mostly oscillated. From the graph, mean maximum temperature reduced from 2010 to 2012 and thereafter begin to increase. It is observed from the time series data that 2010 and 2012 recorded the lowest and the highest maximum temperature of 31.00C and 31.80C respectively. The trend equation and the trend line of the mean maximum temperature generally shows and decreasing trend (-0.105x) which means that the average maximum temperature over the years (2010 - 2014) has been decreasing. The degree of variation (R2 =0.0037) shows the variability in maximum temperature in the area.

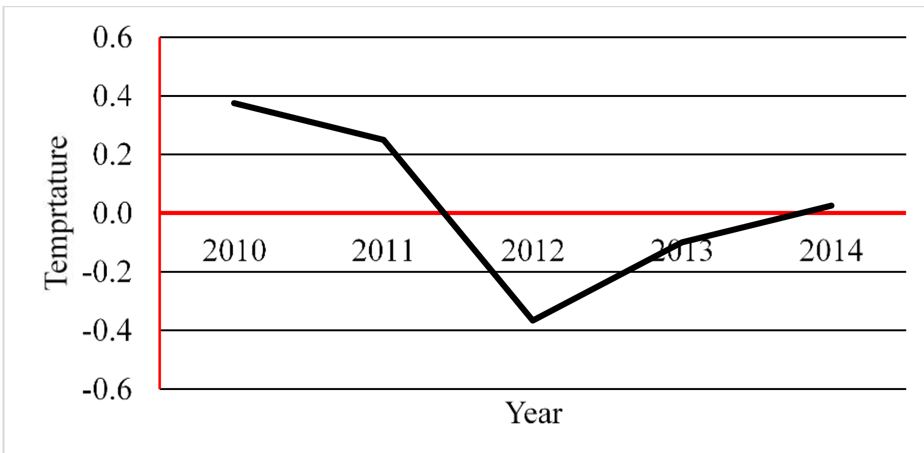

Figure 8: Variations in mean maximum Temperature for Cape Coast (2010- 2014)

Source: Field Data, 2015

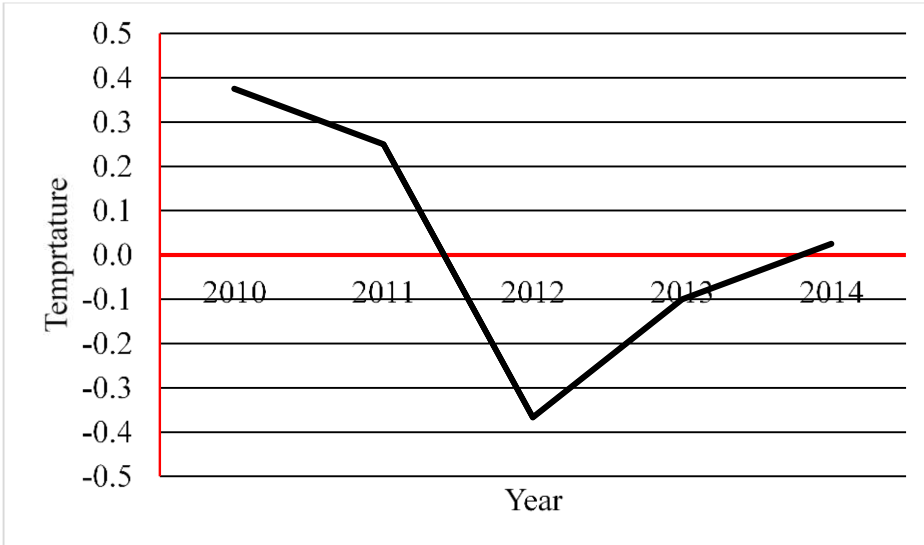

Figure 9: Anomalies in mean maximum Temperature for Cape Coast (2010- 2014)

Source: Field Data, 2015

It is evident from the inter-annual variability graph that there are anomalies in the maximum temperature as observed in the time series data with a greater number of the mean values being positive. This would influence the overall variability of temperature within the time period. These are indications that the district is becoming cooler due to the rich vegetative cover in the district. This condition could influence the cultivation of cocoa. When the area becomes cool the relative humidity of the area would be high. This increases the susceptibility of the cocoa trees to incidence of disease infestation especially black pod disease which destroys cocoa pods and consequently reduces harvest from the farm. This eventually reduces the income of the cocoa farmers.

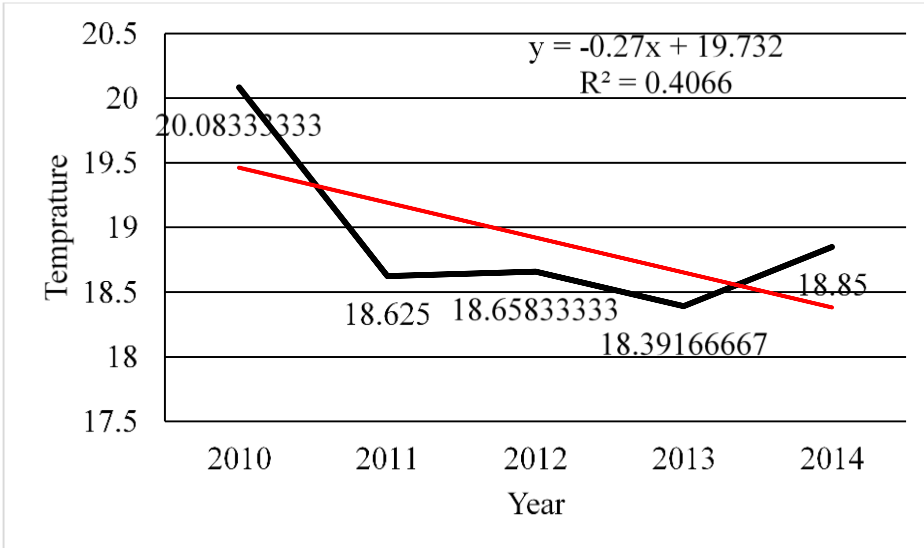

Figure 10: Variations in mean minimum Temperature for Cape Coast (2010- 2014)

Source: Field Data, 2015

The trend in the variation of the minimum temperature shows a decreasing trend from 2010 to 2014. It can be observed that from 2010 temperature has been decreasing steadily over a period till it started to increase from 2013. The degree of variation is 0.4066 this shows that the variability in minimum temperature in the area is approximately less than 1 percent. This shows a decrease in temperature and such shifts have a bearing on cocoa production – it provokes disease incidence and leads to premature ripening of cocoa pods. Black pod disease is the most destructive of a number of diseases, which attack the developing or ripening cocoa pod. This was reinforced by the assertion made by the senior agricultural extension officer who retorted that:

"Black pod disease is more prevalent in damp situations and is most destructive in years when the short dry period from July to August is very wet". (A 44-year old man).

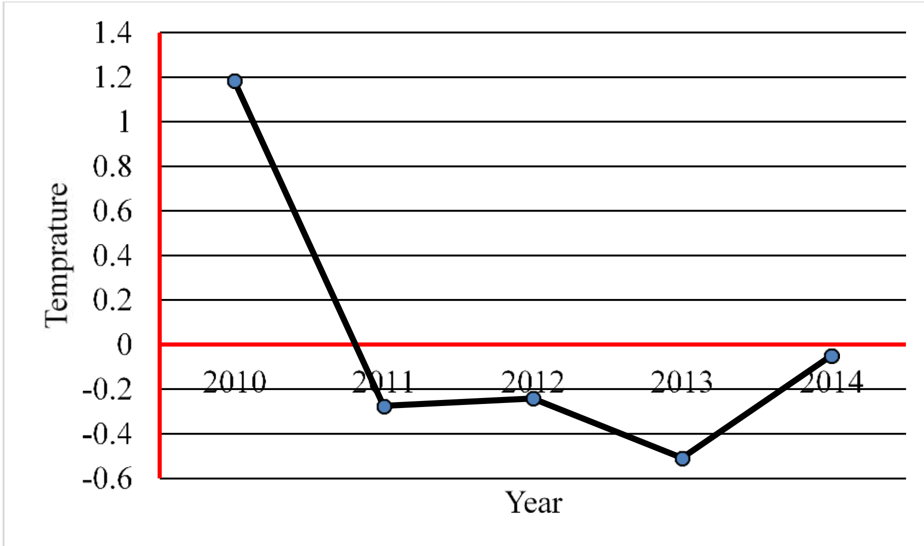

Figure 12: mean minimum Temperature for Cape Coast (2010- 2014)

Source: Field Data, 2015

It is evident from the inter-annual variability graph that there are anomalies in the minimum temperature as observed in the time series data with most of the mean values being negative. The implication of a decrease in the minimum temperature to crops in general is that, it will affect photosynthetic activities of crops which may in the long run affect the yield of crops especially cocoa. Temperature has been related to light use efficiency with temperatures below 24oC having a decreasing effect on the light saturated photosynthesis rate. Low light intensities however suppress flower production with light levels less than 1800 hours year-1, having a considerable depressing effect on production.

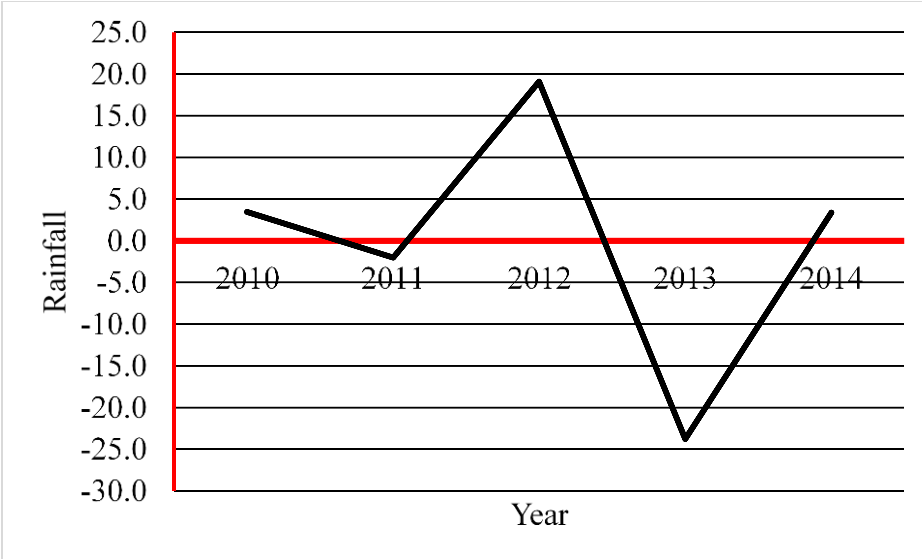

Figure 12: Variations in mean annual Rainfall for Cape Coast (2010- 2014)

Source: Field Data, 2015

Figure 14 shows, that rainfall declined from 2010 to 2011 and later increased steadily in 2012 after which it decline again in 2013 and then later on increase in 2014. It is obvious from the graph that rainfall indeed experienced a number of variations over the period under consideration (2010-2014) with the highest rainfall (95.0 mm) occurring in 2012 and the lowest of 52.2 in 2013.

The trend equation and the trend line of the annual rainfall shows a gradual decreasing trend (-2.1933x) which means that the annual rainfall pattern over the years (2010-2014) has been decreasing at a steady rate. This also means that even though rainfall seems to be decreasing over the periods, the trend of decrease is generally gradual. The decreasing rainfall would results in soil water deficit and since irrigation is not part of the farming system, cocoa seedling mortality is high during the establishment phase. In bearing plants, the existence of the short dry season during main crop pod filling can affect bean size if it is sufficiently severe. In adult plantings, water deficits result in lower yields and an increase in the level of mired damage. The implication of the inter-annual rainfall analysis shows that the decrease in rainfall in the district has the potential to affect cocoa which need rainfall, especially during the fruit development stages. It was also observed that the rainfall peaks were in June and October due to the bimodal nature of the rainy season in the district. The peak of the major season was in June while that of the minor season was in October. However, there was uneven distribution of rainfall in the months with the pattern being unreliable over the years. This potentially could have affected most cocoa farmers in the district who needed the rains after planting.

This observation is consistent with the work of (McSweeney et al., 2008) whose study revealed a general decreasing rainfall trend of 2.4 percent per decade across Ghana between the periods of 1960 and 2006. However, it was observed during the focus group discussion that, even though the onset of the rainy season delays in the district, the amount of rainfall has increased.

A male discussant of the focus group discussion retorted that:

“It doesn’t normally rain but when it does; it comes heavily which mostly destroy our cocoa. Since most of us depend on the cocoa for our livelihoods, a reduction in yield affects us a lot especially in taking up social responsibilities like sending our children to school” (A 50-year old man).

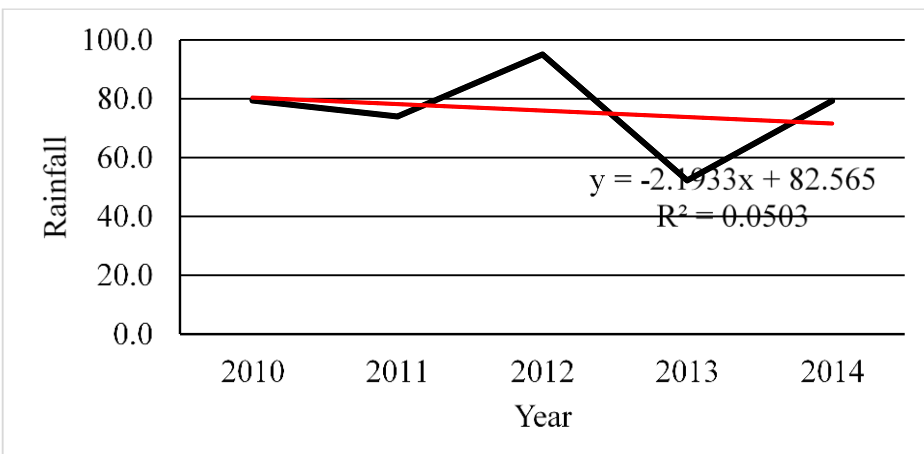

Figure 13: Anomalies in mean annual Rainfall for Cape Coast (2010- 2014)

Source: Field Data, 2015

It is also observed that anomaly of the inter-annual rainfall variation shows the amount of rainfall that has varied from year to year (See Figure 13).

It shows from the trend anomalies that rainfall variability has been oscillating within the 5 year period.

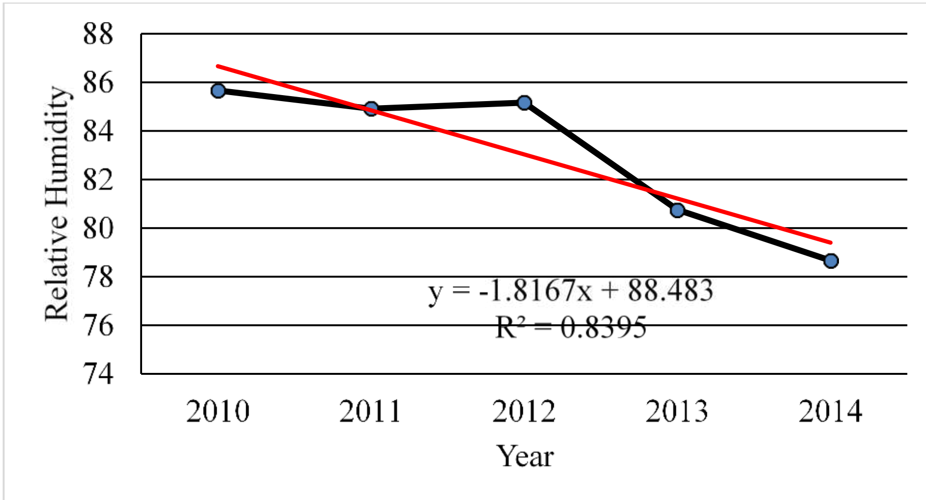

Figure 16: Variations in mean annual Relative humidity for Dunkwa –on- Offin (2010- 2014).

Source: Field Data, 2015

Figure: 14 shows, the variations in the mean annual relative humidity at Dunkwa-on-Offin for the period 2010-2014. Although relative humidity decreased between 2010 and 2014, there were great variations. Relative humidity decreased from 85.6mm in 2010 to 84.9mm in 2011. It then increased to 85.2mm in 2012 and decreased sharply to 80.7mm in 2013 and further decreased to 78.6 in 2014 which was the lowers figure recorded over the study period. The relative humidity anomalies in figure: 14, shows a decreasing trend which indicates that the relative humidity at the Dunkwa –on –Offin District is decreasing. This have an effect on cocoa production because reduced relative humidity would result in the dryness of the air which can lead to the dryness of the cacao leaves due to evapotranspiration.

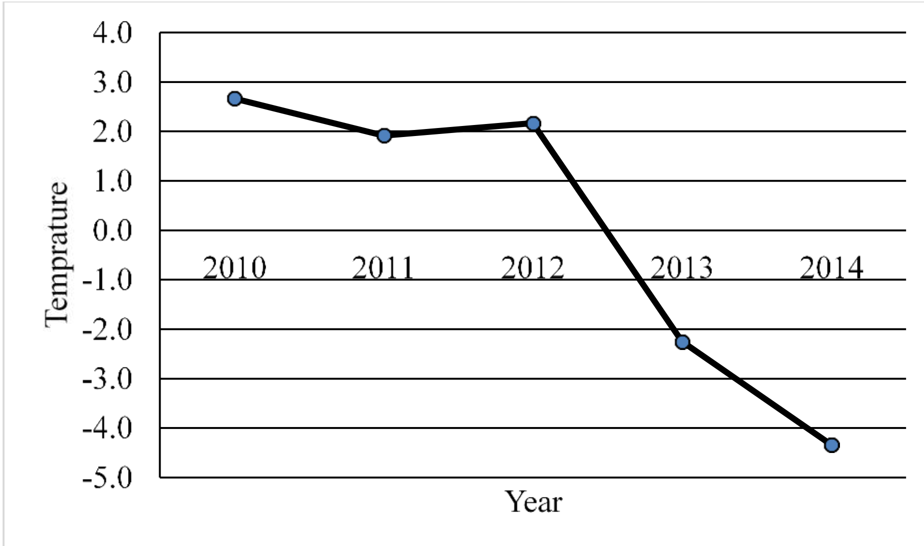

Figure 15: Anomalies in mean annual Relative Humidity for Dunkwa- on -Offin (2010- 2014)

Source: Field Data, 2015

Figure: 15 show, the variations in the mean annual relative humidity at Cape Coast for the period 2010-2014. Although relative humidity increased between 2010 and 2014, there were variations. Relative humidity increased from 81.2 mm in 2010 to 82.1mm in 2011. It then increased to 83.4mm in 2012 and remained the same in 2013 and further increased marginally to 83.5 in 2014 which was the highest figure recorded over the study period.

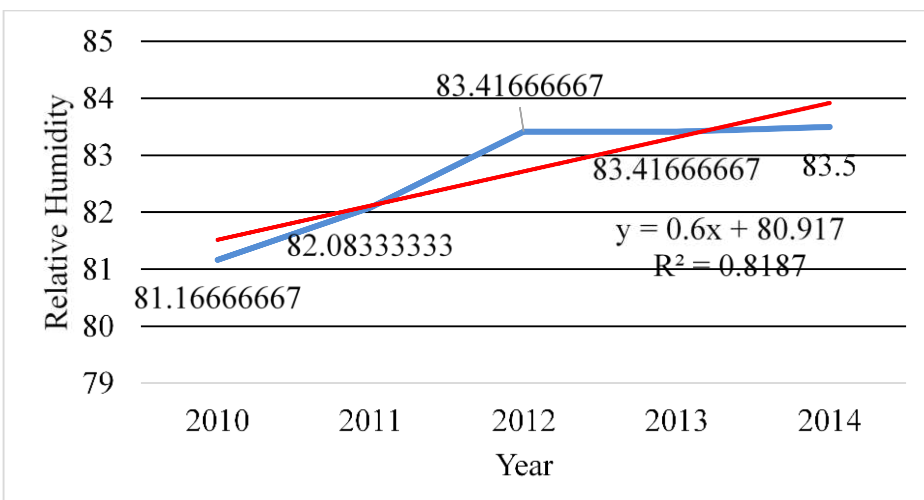

Figure 16: Variations in mean annual Relative humidity for Cape Coast 2010 - 2014

Source: Field Data, 2015

The relative humidity anomalies in figure: 16 shows an increasing trend which indicates that the relative humidity at the Cape Coast District is increasing but at a steady rate. The relative humidity in cape coast cocoa District is fairly constant from 2012 to 2014.

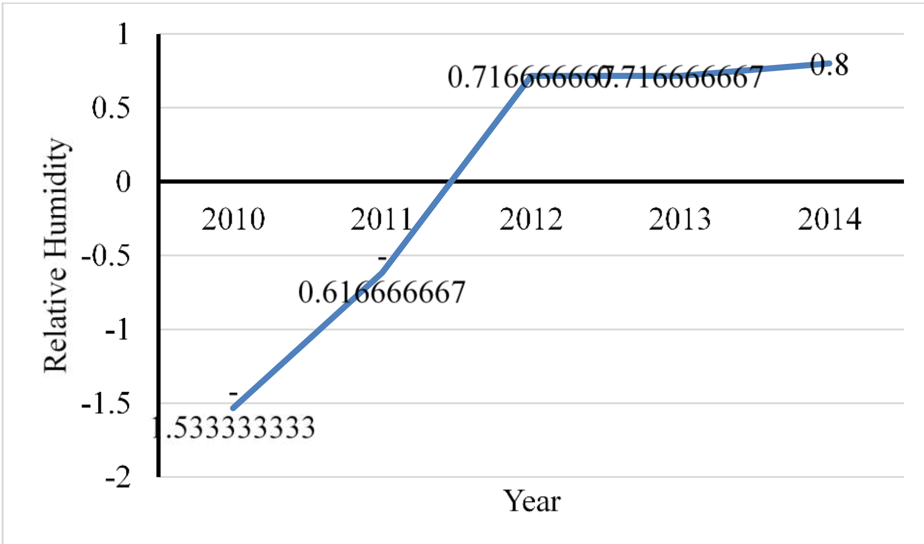

Figure 17: Anomalies in mean annual Relative Humidity for Cape Coast (2010 – 2014)

Source: Field Data, 2015

4.3 Variations in Cocoa Output for Cape Coast and Dunkwa-On-Offin (2010 – 2014)

Figure 18 shows that cocoa production has varied over the five year period (2010-2014) in the Cape Coast and Dunkwa-on- Offin cocoa Districts. Cocoa output decreased sharply from 2010 to 2011 and then rose significantly in 2012 Cape Coast District. The decrease in production could be attributed to the variation in mean annual rainfall during the period as shown in figure 13. Again the mean maximum temperature in the Cape Coast District reduced from 2010 to 2012 and thereafter begins to increase.

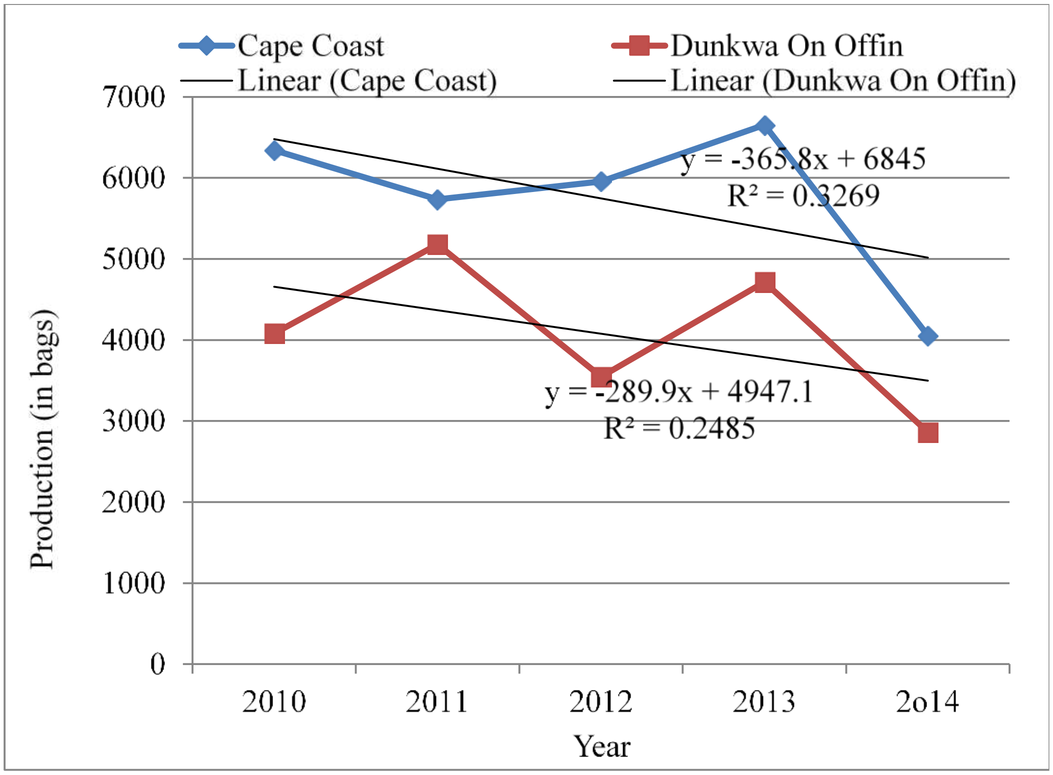

Figure 18: Variations in cocoa output for Cape Coast and Dunkwa-on-offin (2010 – 2014).

Source: Fieldwork, 2015

It is observed from the time series data that 2010 and 2012 recorded the lowest and the highest maximum temperature of 31.00C and 31.80C respectively which could be the cause of the cocoa output. Cocoa season in Cape Coast District in 2013 recorded the highest ever within the five year period under study. Again, there was a sharp decrease in cocoa output from 2013 to 2014 which recorded the lowest in the study period. It is observed from the time series data that 2014 and 2013 recorded the lowest and the highest cocoa output respectively.

The Dunkwa-on–offin District graph shows an increase in cocoa output from 2010 to 2011. During the same period mean annual rainfall for the District increased. There was a sharp decrease in 2012 and a significant increase in 2013 before showing some level of decrease in 2014. The trend equation and the trend line of the cocoa output generally shows a decreasing trend (289.9x) which means that the cocoa output over the years (2010- 2014) has been decreasing. The degree of variation (R2 =0.248) shows the variability in cocoa output in the area.

Generally the graph shows a decreasing trend in cocoa output in both Districts.

Recommendations

This section provides a policy framework that seeks to guide policy makers in designing programmes that could enhance farmers knowledge on seasonal variations in climatic elements to enable them respond to the pressures and risks of the seasonal variations in climatic elements as observed in the Central Region of Ghana. Based on the findings of the study, these recommendations are proposed.

• It evident that the existing agencies and government bodies have not been responsive enough in addressing the climatic problems, forecasting skills and opportunities facing cocoa farmers as crucial factors of risk posed by seasonal variations in climatic elements. The study advocates that government and stakeholders should put up educational programmes tailored to meet the climatic information needs of farmers especially the causes to enable them cope with the emerging challenges to enhance their production. This could be realized through effective extension services. To achieve this, the Ghana Meteorological Agency should be well equipped to give accurate information about the weather. NGOs and other private partners in and outside the cocoa sector should be fully involved in the education and sensitization of farmers on issues bordering seasonal variations in climatic elements, causes and controls.

• From the foregoing, it is recommended that government should increase subsidy to cocoa farmers to enable them purchase pesticides, fertilizers and the needed farm inputs that can help farmers cope with emerging pest and diseases that have emanated as a result of seasonal variations in climatic elements to improve production of cocoa.

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