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IMPACT OF CLIMATE CHANGE ON WEST AFRICA COCOA YIELD: EVIDENCE FROM Cote D'Ivoire

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Abstract

This study examines the relationship between current cocoa yield status and climate change in Côte d'Ivoire. Autoregressive Distributed-Lag (ARDL) proposed by Pesaran et al (2001) is used to analyze the relationship between cocoa production, temperature, rainfall, labor and production area from 1990-2020. First, we found a positive relationship between rainfall and cocoa production in the short run while this relationship is negative in the long run. Second, higher temperatures affect cocoa production in the short run, but the influence of temperature on cocoa yield is positive and significant in the long run. The factor that is not significant in the long run is cultivated area, which is however significant and has a negative effect on cocoa yield in the short run. The relationship between cultivated area and cocoa yield is due to the fact that the profitability of cocoa decreases for farmers cultivating larger areas. In addition, it takes a few years for planted cocoa to mature and start yielding. Therefore, climate change affects cocoa yields in the case of Côte d'Ivoire. This result may imply that policy makers should inform the Ivorian population about the consequences of climate change on cocoa production through publicity and awareness structures. Second, they should encourage agricultural research to create a more rain-resistant cocoa bean. Finally, the Ivorian government should focus its investments on educating the rural population and showing them the importance of weather reports as an agricultural forecasting tool.

Keywords: Cocoa yield, climatic change, Cote d'Ivoire

INTRODUCTION

Cocoa is considered in Africa as the Fruit of the gods (Theobroma cacao). This is owing to the countless benefits it provides to the entire world. Health, scientific, environmental, financial, and economic benefits are among these benefits (Lima et al., 2011). Minerals such as magnesium, iron, copper, phosphorus, calcium, and manganese are found in cocoa powder and beans. Potassium, selenium, and zinc are all abundant. Cocoa beans can help with constipation, cholesterol, obesity, high blood pressure, cancer, bronchial asthma, diabetes, neurodegenerative disease, and chronic fatigue syndrome, to name a few (Tardzenyuy et al, 2020). It improves cardiovascular, cutaneous, and cognitive health as well as wound healing. It can also be used to treat copper deficiency. It contains anti-neurotoxic effects and boosts mood. Aside from these benefits, cocoa cultivation promotes economic growth and the well-being of rural residents.

It is worth mentioning that West Africa produces 70% of the world's cocoa, while Cote d'Ivoire produces 40% of its chocolate (Fold, 2001 & Schroth et al., 2016). Cote d'Ivoire's agriculture sector generates significant revenue for the country and contributes significantly to its economic development, accounting for 23.19 percent of GDP structure in 2020 (Moody & ADF report 2021). Besides, A significant section of Cote d'Ivoire's population is dependent on the commercial benefits of cocoa cultivation and supply lines.

The prime reason that West African countries, particularly Cote d'Ivoire, are among the top producers of cocoa is that they have optimal climate conditions for farming the cash crop (Abu et al., 2021). Scientific specialists have demonstrated a link between crop output and climate characteristics; hence, any environmental circumstance that may affect agricultural production should be investigated.

A cursory examination of the scientific evidence on climate change and its implications for agriculture indicates that the topic of this research is both fascinating and evolving.

The study's fundamental goal is to analyze the effects of climate change on cocoa yield in Cote d'Ivoire. The following assessment is taken into account in the study's objectives:

1. To identify the positive impact of climate variables on yield production.
2. To determine the climate variables which negatively impact yield production.

In effect, growing cocoa necessitates more stringent pedological and climatic conditions than other tropical crops such as palm, coffee, and rubber. Cocoa, for example, requires wetter circumstances with a minimum annual rainfall of 1200 mm to 1500 mm and a limited number of dry days (90 days) for its development.

From 1960 to 1990, climatic change created drought events that were sequences of continuous rainfall deficiency periods that were limited to the Sahel and spread to the coastal

regions of West Africa, particularly in Côte d'Ivoire. The dry circumstances caused a significant disruption in water supplies, which ultimately turned into a calamity for the people, resulting in cattle losses and the gradual extinction of certain export crops. Hence, climate change has influenced worldwide agricultural production by altering temperature and precipitation patterns.
The agriculture sector's reliance on climate change is a quite important concern for economic development. The majority of the country's population lives in rural areas is engaged with agricultural and non-agricultural related activities (World Bank, 2014).

Farmers constantly find ways to adapt to the variations in the weather and climatic conditions. However, environmental and global climate change has expanded the scale needed for farmers to develop and implement resilience strategies (Aiello, 2009; Collier, 2013; Hess, 2003). Practically, all economic sectors are susceptible to climate change, but agriculture is the most. Climate change will address crop productivity issues through changes in the rainfall patterns, sowing and harvest dates, rising temperatures, water supplies and transpiration (Rosegrant et al., 2008; Zenghelis, 2006).

Climate change will adversely affect the production of crops and may contribute to food security issues (Kirby et al., 2016; Mendelsohn, 2014; Mirza, 1997; Misra, 2014; Pearce et al., 1996; Spash, 2007).

One of the most important positive effects of the increase in temperature, especially in middle and higher latitudes (e.g., USA, Europe, Australia), is improving the conditions for crop growth through extending the length of the potential growing season, reducing the growing period required by crops for maturation, and thus allowing earlier maturation and harvesting, as well as increasing the possibility of completing two or more cropping cycles during the same season and the likelihood of expanding the crop-producing areas, despite the probability of decreasing the yields in higher latitudes due to the less fertile soils that lie there (Rosenzweig and Daniel 1995).

However, warming tends to reduce yields beyond a specific range of temperatures because crops speed through their development, producing less grain in the process. And higher temperatures also interfere with the ability of plants to get and use moisture. Evaporation from the soil accelerates when temperatures rise, and plants increase transpiration—that is, they lose more moisture from their leaves. The combined effect is called "evapotranspiration." Because global warming is likely to increase rainfall, the net impact of higher temperatures on water availability is a race between higher evapotranspiration and higher precipitation to land quality, climate, fertilizer inputs, and so forth (Rosenzweig and Iglesias, 2006).

On the other hand, increased temperature in warmer/lower-latitude regions is expected to accelerate the respiration rate, at which plants release CO_2, causing less than optimal conditions for net growth (Rosenzweig and Daniel 1995), and increasing the evaporation rates, therefore, reduces the moisture availability which then affects the yields' negatively (Parry 1990). Moreover, higher temperatures during the growing season speed the development of annual crops, especially in the grain-filling stage, thus allowing less grain to be produced (Downing 1996): So, crop growth in most of the developed countries (middle and higher latitudes) will benefit from the increase in temperature, comparing to the developing ones (lower latitudes) which will be negatively affected.

In most parts of China, climate warming usually shortens the growth cycle of food crops, which leads to demur the average production (Huang et al., 2010; Wang et al., 2014). Because of the numerous seasonal droughts, there is a spatial and temporal gap between precipitation and irrigation, ensuring adequate challenges in irrigation and water supply (Zhang et al., 2006).

Abid et al. (2015) reported that livelihoods of the rural households and the yield of primary food and cash crops, including wheat, rice, cotton and sugarcane, had heavily affected over the past two decades because of variations in the global climate.

Recently, some authors have investigated the impact of climate change on cereal yield, agriculture and economic growth by using several econometric techniques.

Dumrul and Kilicaslan (2017) used the ARDL bounds testing approach and found a positive and significant impact of precipitation on agriculture output, while temperature has a negative impact on agricultural output in Turkey.

Rahim and Puay (2017) examined the nexus between climate change and economic growth in Malaysia. The time frame for the study was 1983 to 2013. The study analyzed the variable using the unit root tests such as the Dickey-Fuller GLS (DF-GLS) and the ADF, the Johansen cointegration approach and vector error correction model (ECM). The variables in the study were the gross domestic product (GDP), precipitation, temperature and arable land. Results of the analysis revealed that there is a long-run cointegration association between the study variables. There is a one-way causality nexus from temperature and arable land to GDP.

An empirical study has been conducted in India by Alam (2013), which examined the response of agricultural output to climatic change and its long-run effect on economic growth by using time-series data between 1971 and 2011. An ARDL approach and ECM based procedures have been used to inspect the short and long-run nexus between CO_2 emissions, agricultural output and economic growth. Findings revealed that there is a negative and significant linkage between CO_2 emissions and economic growth, while there is a positive and significant association between agricultural output and economic growth.

A study by Asuamah Yeboah et al. (2015) examined the impact of CO_2 emissions on cereal production in Ghana by using the ARDL approach. The time-series data for Ghana from the period of 1961-2010 is used; findings of the empirical analysis revealed that there is a significant unenthusiastic linkage between CO2 emissions and cereal production while there are positive and significant short and long-run relationships between cereal production and income. Furthermore, Rehman et al. (2019) studied the link among CO2 emissions and agricultural productivity in Pakistan, by using ARDL bounds testing approach. They found that cropped area, energy usage, fertilizer offtake, GDP per capita and water availability had a significant association with CO2 emissions, while improved seed distribution and total food grains revealed a negative association with CO2 emissions in Pakistan.

Lawal et al. (2007) found that a combination of appropriate temperature, limited rainfall, and relative humidity can increase yield and reduce disease incidence in cocoa production in Nigeria, while Dell et al. (2009) used macro data to find that temperature has a favorable impact on economic activity (agricultural produce exports) in both developing and developed countries, whereas precipitation had no effect.

Using a cross-sectional approach to estimate net revenue from agriculture produce, Muzari et *al*. (2016) discovered that agriculture is particularly susceptible to climate change in Zimbabwe. However, the impact of climate variables on agricultural production was not limited to temperature or precipitation. For Kehinde et *al*. (2021), rainfall, temperature, and sunshine are the most important climatic factors that affect cocoa production.

To the best of our knowledge, no empirical study has been done in the context of Cote d'Ivoire to investigate the effects of climate change on Cocoa output.

The rest of the study is organized as follows: the analysis method is provided in section 2, Empirical results and discussion are presented in section 3, and finally, section 4 is the conclusion, policy recommendations, study limitations.

RESEARCH METHOD

The theoretical framework is based on crop yield response theory and employs the transcendental logarithm (translog) function, which is a descendant of the production theory's flexible, functional form. Koppen (1918), Lang (1920), Martonne (1926), Angstrom (1936), and Thornthwaite (1948) are proponents who integrate precipitation and temperature to create composite aridity indices. Ofori-Boateng and Insah (2014) employed this concept in their studies. The research will take a similar course. According to their availability, this analysis data is from 1990 to 2020.

We utilize yearly climate data (precipitation and temperature) from the World Development Indicators (WDI, 2020) and the non-climatic factors from the United Nations Food and Agriculture Organization (FAOSTAT, 2019).

The time series model specification

The crop yield response theory literature distinguishes between two inputs: growth inputs and facilitation inputs (Chambers and Lichtenberg 1994, 1996; Sauer et al., 2007). According to Guan (Guan et *al*., 2006), growth inputs include seed type, nutrients, and water, which are all directly engaged in the biological process of crop growth and hence crucial for crop growth. Growth inputs establish the most significant production level that may be achieved in a given biophysical environment, assuming no yield-reducing factors such as weeds, diseases, or pests.

On the other hand, facilitation inputs are those that are not directly engaged in the fundamental biological process but can aid in the creation or modification of growth circumstances under which growth inputs are adequate (Guan et *al*., 2006). The growth inputs identified for cocoa production in this study are temperature, which acts on the tree's physiology, and precipitation, which acts on the tree's roots system, while species features are held constant and no growth limiting and lowering variables are assumed. The enabling inputs are now identified as Labor and Capital, per the study's context (in the form of Fertilizer rather than machines). Cocoa output for Cote d'Ivoire is, therefore, characterized as a function of this growth and facilitating inputs

$$Y_t = f\left(X_t\right) \quad (1)$$

Where: Y_t is the output of cocoa from Cote d'Ivoire and X_t are the vector of inputs comprising both growth and facilitating inputs. In specific terms, the X_t is given as:

$$X_t = \left(L_{it}, K_{it}, T_{it}, P_{it}, S_{it}\right) \quad (2)$$

Where:

L_{it} refers to labor input to the production of cocoa in country *i* and in time *t* (Effective labor in agriculture is used in the respective countries). Owing to the fact that there is no specific information on labor in cocoa production for the various countries, it became necessary to use effective labor in agriculture;

K_{it} refers to capital input to the production of cocoa (Fertilizer import for cocoa is used as a proxy). Fertilizer import is used while holding for insecticides, herbicides and so on because it is not easy to identify which chemicals go into cocoa production and which go into other crops. One, therefore, holds the assumption that there are no growth limiting and reducing factors;

T_{it} refers to an exogenous temperature growth input for cocoa growth in country *i* and in time *t*. As stated earlier, temperature acts on the physiology of the cocoa tree which could increase or reduce its growth;

Pit refers to an exogenous precipitation growth input for cocoa production in country *i* and in time *t*. Precipitation acts on the rooting system of the cocoa tree which can improve or reduce the growth of the tree;

S_{it} refers to cultivated area in hectares.

By substituting equation (2) into equation (3), we have:

$$Y_t = f\left(L_{it}, K_{it}, T_{it}, P_{it}, S_{it}\right) \qquad (3)$$

We use the translog function of the time series to get symmetrical terms, which we can then use to create a dynamic translog model by inserting *p* lags on climatic variables and *q* delays on the dependent variable, as in Koissy et *al.* (2020) and Zhengfei et *al.*, (2006). We obtain an equation that will be estimated through an Autoregressive Distributed-Lag (ARDL) model.

The Autoregressive Distributed-lag model contains the lagged value(s) of the dependent variable, the current and lagged values of regressors as explanatory variables. Also, the model uses a combination of endogenous and exogenous variables and tests for unit root to ascertain that no variable is integrated of order 2 (I (2)).

The ARDL model can be specified, if the variables are integrated of different orders. That is, a model having a combination of variables which are integrated at level (I (0)) and at first differences (I (1)). Furthermore, the bounds test result highlights the nature of the cointegration among the studied variables. Using the ARDL model permits to obtain unbiased long-run estimates. The ARDL model is as following:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \ldots\ldots + \beta_p y_{t-m} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \ldots\ldots + \alpha_q x_{t-n} + \varepsilon_t \qquad (4)$$

The generalized ARDL model from this above model is specified as:

$$Y_t = \gamma_{0i} + \sum_{i=0}^{p} \delta_i Y_{t-i} + \sum_{i=0}^{q} \beta_i^{'} X_{t-1} + \varepsilon_t \qquad (5)$$

Where

Y_t is a vector and the variables in X_t are allowed to be purely I (0) or I (1) or cointegrated;

β and δ are coefficient; γ is the constant; $i = 1, \ldots\ldots K$; *p,q,* are optimal lag orders;

ε_{it} is a vector of the error terms- unobservable zero mean white noise vector process (serially uncorrelated or independent).

The final equation is:

$$\Delta \ln Y_t = \ln A + \sum_{p=1}^{P} a_y \Delta \ln Y_{t-p} + \sum_{q=1}^{Q} a_L \Delta \ln\left(L_{t-q}\right) + \sum_{q=1}^{Q} a_K \Delta \ln\left(K_{t-q}\right) + \sum_{q=1}^{Q} a_S \Delta \ln\left(S_{t-q}\right) + \sum_{q=1}^{Q} a_T \Delta \ln\left(T_{t-q}\right) + \sum_{q=1}^{Q} a_p \Delta \ln\left(P_{t-q}\right) +$$
$$\ln Y_{t-1} \gamma_{KS} \Delta \ln\left(K_{t-q}\right) \ln\left(S_{t-q}\right) + a_1 \ln\left(L_{t-1}\right) + a_2 \ln\left(K_{t-1}\right) + a_3 \ln\left(S_{t-1}\right) + a_4 \ln\left(T_{t-1}\right) + a_5 \ln\left(P_{t-1}\right) + a_6 \ln\left(K_{t-1}\right) \ln\left(S_{t-1}\right) + \varepsilon_t$$

(6).

RESULTS AND DISCUSSION

The descriptive statistics in Table 1 shows that cocoa yields in Côte d'Ivoire averaged 6.0626 kg/ha from 1990 to 2020. Given that cocoa production is mainly concentrated in rural areas, it is critical to examine the rural population's share of the total population. Cote d'Ivoire's rural population accounted for 62.23 percent of the total population. The highest recorded rural population percentage in the early days of the country's independence from colonial rule in 1961 was 81 percent. This was significant because it produced a massive workforce for agricultural productivity. The average temperature in the country throughout the research period was 26.76°C. The lowest temperature ever recorded was 24.32°C, while the highest was 30.30°C. The nation's average annual rainfall was 1.1253 millimeters. This workforce and the combination of temperature and rainfall might be one reason for cocoa yield production in the studied period.

Table 1: Descriptive table

	Yield (Yt)	**Labor (Lt)**	**Capital (Kt)**	**Temperature (Tt)**	**Precipitation (Pt)**	**Area cultivated (St)**
Mean	6.0626	6.7967	1.4915	26.7563	1.1253	1.8027
Max.	6.4537	6.8933	4.1302	30.30 24	1.2129	1.8239
Min.	5.6616	6.6621	0.0113	24.3232	1.0570	1.7751

The following table (Table 2) shows the stationarity level of the studied variables. The results of augmented Dickey-Fuller (ADF, 1979, 1981) and Phillips-Perron (PP, 1988) tests show that the variables are stationary at level (I (0)) and first difference (I (1)). The variables Yield (Yt), Capital (Kt), Temperature (Tt), Precipitation (Pt), area cultivated (St) are stationary at First difference (I (1)) while Labor (Lt) and Precipitation (Pt) are stationary at level (I (0)).

Table 2: Unit roots tests

Variables	**ADF**		**Phillips-Perron**	
	I (0) Level	I (1) First difference	I (0) Level	I (1) First difference
Yield (Yt)	-1.211	-5.972***	-0.830	-7.972***
Labor (Lt)	-4.624***	-2.490	-3.022**	-2.267
Capital (Kt)	-1.029	-6.488***	-1.029	-6.657***
Temperature (Tt)	-0.380	-4.141**	-2.378	-18.843***
Precipitation (Pt)	-80.790***	-4.088**	-87.894***	-156.678***
Area cultivated (St)	-1.054	-3.779***	-1.066	3.779***

*, **, *** denote the statistical significance at 10%, 5%, 1% level

The Bounds test (Table 3) of Pesaran, Shin, and Smith (2001) is the most relevant when dealing with mixed order of integration. It allows checking the long-run cointegration between the studied variables. We employ this test because it gives rigorous results for a small sample and allows multiple predictors to have different lag orders (Sarkodie and Adams, 2018).

The null hypothesis for the Wald test assumes no cointegration while the alternative hypothesis assumes cointegration among variables. When the null hypothesis of no cointegration is rejected (cointegration among variables), it also means that the calculated F-statistic is greater than the upper bound critical value. If the computed F-statistics is less than the lower bound critical value, then we cannot reject the null hypothesis of no cointegration.

We utilize the Akaike Information Criterion, which suggests that our ARDL model's best lag order is (1, 0, 0, 1, 0, 1). Table 3 displays the results of the Bounds test. As a result, the F-statistic produced 2.725, so we reject the null hypothesis of no cointegration and conclude that the variables are cointegrated.

Table 3: Bound cointegration test

	F-statistic		Conclusion
Critical values	2.725		Cointegration
Significance level	I (0)	I (1)	
1%	2.82	4.21	
5%	2.14	3.34	
10%	1.81	2.93	

We proceed to estimate our ARDL model based on the bounds test findings. Table 4 below summarizes the findings. This backup the Bound test results and supports the idea of a long-term connection between cocoa yield and the collection of explanatory factors.

Let's have a look at the coefficients in the long term. The rainfall variable is shown to be negative and substantial. To put it another way, too much rain lowers cocoa production. The calculated coefficient, -0.623 which may be read as rainfall elasticity, is implying that a 1% increase in rainfall over time would result in a 0.623 percent drop in cocoa yield. This is consistent with Hutchins et *al.* (2015)'s estimate of the impact of climate change on the cocoa output. They discovered that higher rainfall intensity affects the blossoming of cocoa tree flowers, resulting in lower tree productivity. The preceding empirical finding clearly shows that there is a long-run causal relationship between precipitation and cocoa yield. Rainfall has a favorable and considerable influence on cocoa output in the near run, unlike in the long run. There is short-run causation from rainfall to cocoa yield here as well.

Let's have a look at the temperature variable now. We find that higher temperatures hurt cocoa output in the short run but that the influence of temperature on cocoa yield is positive and significant in the long run. In effect, a 1% increase in the temperature rate, in the long run, increase cocoa yield by 0.413 percent.

Regarding the above results, cocoa producers and government have to pay attention to the climate change while producing and implementing the policies. In fact, cocoa producers have to consider the combination of precipitation and temperature in order to find the adequate production period while government may implement policies in order to protect environment and which pay attention to the climate change. Those policies might be setting a specific production period, to teach the producers the best way to produce without affecting the environment.

The gross fixed capital formation (GFCF), which is a proxy for investment (Kt), and rural population, which is a proxy for labor (Lt), have a positive influence on cocoa yield. From our table, we can see that 1 percent increase in investment will contribute to an increase of 0.208 percent of cocoa yield while an increase of the labor force by 1 percent will lead to 2.095 percentage positive change in cocoa yield. The factor that is not significant is cultivated area in hectors (St).

These results also show that private investment and labor contribute to cocoa production. So, in order to increase this production, Government should encourage private investment and rural population by setting taxation policies and develop regional projects to motivate young rural population to stay.

In table 4, the p-value of 0.634 in the Jarque-Bera normality test (Jarque-Bera, 1980), which is higher than 0.05 (5%) allows the acceptance of the null hypothesis (H0: the data are normally distributed).

In the case of the Breusch-Pagan-Godfrey heteroskedasticity test (Breusch-Pagan, 1979), the null hypothesis H0 (H0=no heteroskedasticity exists) is also accepted as the p-value (1.062) is higher than 5%. Besides, the Figure 1 and Figure 2 show that the model is stable.

Hence, the normality, heteroscedasticity, and stability tests (Figure 1 and figure 2) permit the bound test to show the robustness of the results.

Table 4: ARDL empirics

Regressors	Coefficient		P-value
Short-run estimates			
∆lnP t	-0.397		0.037
∆lnT t	-0.147		0.058
∆lnLt	1.335		0.075
∆lnK t	-0.133		0.000
∆lnSt	-1.858		0.531
ECT	-0.637		0.000
Long-run estimates			
lnPt	-0.623		0.066
lnTt	0.413		0.035
lnLt	2.095		0.006
lnKt	0.208		0.000
lnSt	0.055		0.128
Diagnostics			**Decision**
CUSUM test	Stability		Model is stable
CUSUMSQ	Stability		Model is stable
Jarque-Bera test	Normality	0.634	Residual are normal distributed
Breusch-Pagan-Godfrey Heteroskedasticity Test:	Homoscedasticity	1.062	

The variables Precipitation (Pt), Temperature (Tt), Capital (Kt) have negative and significant effect on cocoa production in the short run while Labor (Lt) has positive effect in the short run.

In the short run, a 1% increase of precipitation, temperature, capital reduces cocoa yield production of 0.397 %, 0.147 %, and 0.133 % respectively.

The variables Temperature (Tt), Labor (Lt), Capital (Kt) have a positive effect on cocoa yield production while Precipitation (Pt) has a negative effect in the long-run.

The capital has a detrimental influence on cocoa yield in the short run. This is due to the fact that investment takes time to have the desired influence on cocoa yield. However, we can observe that this variable has a favorable influence on cocoa yield in the long run.

When we consider the relationship between the cultivated area and cocoa yield, we found a negative (-1.858) and significant coefficient in the short run. This indicates that a 1% increase in the cultivated area significantly reduces the yield by 1.858 %. This result is in line with Vigneri et *al*. (2016) findings that cocoa profitability declines for farmers cultivating larger areas. The area cultivated remains insignificant in the long run. The reason is that it takes some years for planted cocoa to mature and start yielding

Figure 1: CUSUM test

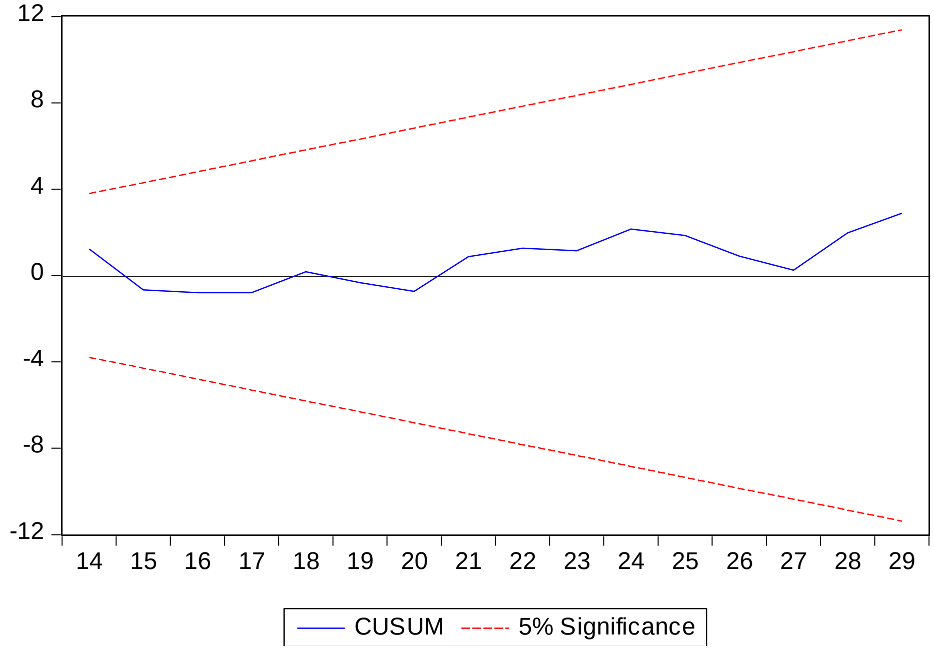
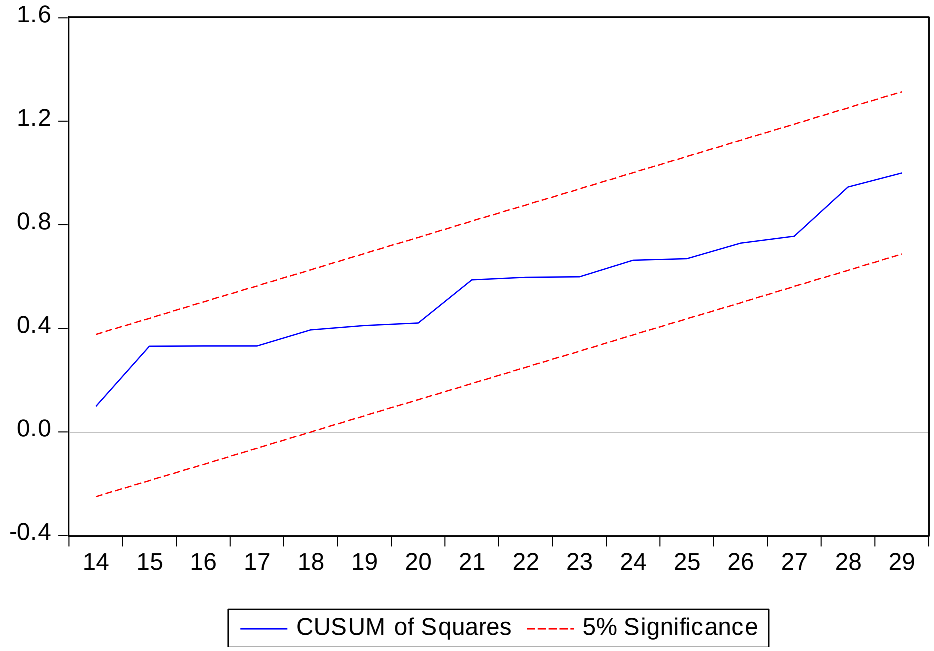


Figure 2: CUSUMSQ test



CONCLUSION

This paper examines the link between climate change and cocoa yield in Cote d'Ivoire for 1990-2020. Using the Autoregressive Distributed-Lag model proposed by Pesaran et *al.* (2001) to analyze the relationship among the cocoa yield, the level of temperature and precipitation, the labor force, the production area, we found that in the short run, precipitation, temperature, and capital have a negative effect on cocoa production while labor has a positive effect. In the long run, only the variable precipitation influences negatively cocoa yield production.

Overall, the results of this paper have three crucial policy implications. First, since the results indicate that cocoa yield is negatively influenced by precipitation, The Ivorian policymakers must inform the Ivorian population on the consequences of climate change on cocoa production through advertising and awareness-raising structures. Secondly, it must also encourage agricultural research to create a cocoa bean that is more resistant to rain. Finally, the Ivorian government must also focus its investments on the education of the rural population and show them the importance of weather reports as an agricultural forecasting instrument.

To end, this analysis can be extended by addressing the role of the level of education in the study of the link between climate change and cocoa yield production. Specifically, it would be to examine the effect of cocoa producer level of education in this relationship. Another important question would be to examine the directions and magnitude of the causality between these different variables.

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