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Climate change effects on economic growth: mixed empirical evidence

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ABSTRACT

West Africa is vulnerable to the effects of climate change. This paper analyzed the impacts of climate change on economic growth in Anglophone West Africa with similar background, during the periods 1969-2016. Five growth model equations have been developed to incorporate climate change variables into the model. Panel data estimations such as the fixed effect model, random effect model and Hausman test were used. The results generated show that four equations required the use of the fixed effect, the agriculture equation model required the use of the random effect model. In the fixed effect models, the results show that the growth of human capital has a negative (-0.08 and-0.23) and significant (0.09* and 0.023*) impact on the growth rate of the services and manufacturing sectors. In Anglophone West African countries, the growth rate of the agriculture sector and temperature are statistically significant (0.008 ** and 0.089*) and have a negative impact (-2.04 and-17.7) on the growth rate of GDP. In the random effect model for agriculture, the growth rate of rainfall has the highest impact on the growth of agriculture in Anglophone West Africa than the impact of temperature on the region. Lack of sufficient rainfall reduces growth of the agriculture sector. In relative terms, change in rainfall pattern is more harmful to agriculture in comparison to the change in temperature in this region. The consequences of climate change in the region are sluggish economic performance and growth, underdevelopment, poverty and human misery.

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INTRODUCTION

Climate change is one of the existential threats confronted by human beings that permeate all aspects of human life be they political, social, ecological, economical etc. The impact of climate change is felt at varying magnitudes across the globe. The focus of this paper is on climate change economic effects on Anglophone West African countries. The materials and methods section of the paper gives an insight on the geographical background and economic trends of Anglophone West African countries. The paper commences with a brief review of the literature on the subject matter. Sillah, (2016), assessed the economic impact of climate change on the Islamic Development Bank (IsDB) member states using cross-

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sectional data and concluded that an increase in Carbon dioxide (CO_2) emission by 1% will result in a decline of real GDP by an average of 0.47% for the dataset. The study found that Sub-Saharan Africa (SSA) member states are the worst region affected by CO_2 emission. It should be noted that 3 out of the 5 Anglophone West African countries are IsDB member. Organization for Economic Co-operation and Development (OECD, 2015), noted that doubling CO_2 emission will cause a GDP loss of about 0.6% to 4.4% by 2060. Consequently, it is vital for emitter of CO_2 to be cognizant of the indirect relationship between CO_2 emission and GDP growth. Numerous studies have pointed out that an increase in temperature has an impact on growth. Abidoye and Odusola, (2015) assert that a 1°C increase in temperature reduces GDP growth by 0.27%. The paper further posits that the impact of climate change is not homogeneous across SSA. This is because SSA is diverse and the countries have their unique geographic and atmospheric features as highlighted in the materials and methods section of the paper. Stern, (2007), further explains that an increase in temperature of 4°C and above will seriously affect global food production thus resulting in a decline in food crop yield, especially in Africa. The rise in temperature will have global ramifications but the severity of the problem will have a huge effect on Africa than other regions in terms of food security. Studies on Africa's rainfall projections are difficult to predict. Pereira, (2017) note that there is a mixed signal of rainfall increases and decreases. The study points out that rainfall projections for West Africa and the Sahel regions are indeterminate. Coulibaly *et al*., (2017) point out how the adverse effects of precipitation will affect Ivorian cocoa export revenue, some of the Anglophone West African countries are neighbours to Ivory Coast i.e. Ghana and Liberia, hence similar conditions may prevail. Mehmood-ul-Hassan and Leeuw, (2015) , stress that African farmers will face challenges of erratic rainfall, frequent and severe droughts in dry lands and savanna areas. Thus, the change in weather patterns will alter the timing and length of cropping seasons which will affect the lives and livelihoods of inhabitants of those settlements in the long run. Bulut and Gürkan, (2017), buttress the need for the development of new species using biotechnological approaches and drought resistance verities that will possess high water use efficiency characteristics. The foregoing, according to the paper, will make provision for future food production in light of climate change. Abidoye and Odusola, (2015), suggest the need for Africa to use research and development for adaptive measures to cultivate drought-resistant crop varieties. The study also stresses the need for the promotion of effective water resource management infrastructure to enhance African agricultural development for economic growth. The implication of delay or inaction in implementing climate policy has serious consequences. Luderer *et al*., (2013), note that a delay in adopting comprehensive climate policies will result in not only higher costs for reaching a given climate target but also an increase of the lower level of climate targets achievable within the range of acceptable cost levels. This emphasizes the urgent and immediate action necessary to reduce the higher cost of inaction or delay in acting. According to the (OECD, 2015), if no policy actions are undertaken, the combined effect of the impact on global GDP is projected to decline by 1% to 3.3% by 2060. It is, therefore, imperative that the necessary policy measures are taken to lessen the cost of inaction or delay which will be colossal for SSA. On the issue of inefficient climate mitigation policies Mendelsohn, (2019), elucidate that the biggest threat climate change poses is not climate-related disasters, but rather aggressive and inefficient mitigation policies which could increase mitigation cost to US $28 trillion. Stern, (2007), point out that inefficient mitigation policies could be costly to society; it can be 14 times higher than optimal mitigation costs. Hence, as demonstrated, misguided inefficient climate change programs and policies will pose a serious threat to economic growth. The threat of climate change in West Africa is aggravated by limited access, awareness of and education about family planning, especially in rural communities, thus contributing to a rapidly growing population in the region. While food production has remained almost constant or increased slowly, therefore food production has not been able to keep up with population growth, resulting in a higher demand for and supply of imported food (Jalloh *et al*., 2013). This situation has increased poverty and deprivation on the continent, thus hindering economic growth significantly in many countries in SSA. United States Aid (USAID, 2011) elucidated that due to climate change in West Africa 3 key sectors will be seriously affected: (1) Food security will be a serious challenge by 2020, with a potential decrease of about 50% in yields from rain-fed agriculture. (2) The health sector will witness extreme weather events such as droughts, heatwaves and storms, thus leading to an increase in the incidents of meningitis, malaria and acute respiratory infections. (3) Water resources will be affected by declines in rainfall, increases in temperature and more frequent droughts which will result in a decrease in surface and groundwater availability and accessibility causing loss of life, decline in agricultural production and the few areas that will be exposed to flooding will experience health and sanitary problems coupled with dilapidated infrastructure.

The current study have been carried out in Anglophone West Africa in 2019.

MATERIALS AND METHODS

Geographical background of Anglophone West Africa

Anglophone West Africa comprises 5 countries (The Gambia, Ghana, Liberia, Nigeria and Sierra Leone) out of the 15 countries that make up the Economic Community of West African States (ECOWAS), i.e. one-third of the countries in the sub-region. These countries were former British colony except Liberia. All of them are located on the west coast of Africa along the Atlantic Ocean where their major seaports and capital cities are also located except Nigeria's capital city, thus making their capital cities and seaports prone to sea-level rise which is a long-term effect of climate change. The total landmass of Anglophone West Africa is 1,503,099 km^2, with a combined population of 246.51 million and an average population growth rate of 2.47% (Fage and McCaskie, 2019). All of these countries have a high population density in their urban areas because their rural communities in most cases lack basic social amenities and infrastructure. Anglophone West Africa is home to Africa's most populous country, Nigeria, and the smallest country on mainland Africa, The Gambia. The topography of Anglophone West Africa is heterogeneously characterized by a diverse terrain of flood plains, lowland plains with dissected plateaus, upland plateaus, coastal plains, hills, mountains, mangroves etc. All these countries have bountiful natural resources. Nigeria and Ghana are endowed with petroleum, whilst Liberia and Sierra Leone are endowed with diamonds and other precious mineral reserves, yet poverty is highly prevalent in these counties. In light of climate variability, the poverty rate in Anglophone West Africa will continue to increase if appropriate policies are not taken. These counties are faced with various degrees of environmental challenges such as drought in the case of The Gambia and Ghana, dust storms in Liberia and Sierra Leone and flooding in parts of Nigeria Central Intelligence Agency (CIA, 2019). Climate change will further exacerbate these environmental problems unless effective remedial measures are taken. Sylla *et al*., (2016) elucidate that West African countries have recorded in recent decades warming temperatures, which increased between 0.3°C and 1°C. On the precipitation front Sylla *et al*., (2016), buttress that precipitation tends to have increased in some parts of the Sahel by about 0.2-1.0 mm per day per decade. Pointing out that in general, the Sahel (which constitutes The Gambia and parts of Nigeria) has experienced wetter conditions while a small part of the Gulf of Guinea (which comprises Ghana, Liberia and Sierra Leone) has recorded drier conditions in recent years. The foregoing is an indication of the erratic nature of climatic conditions in the sub-region. This has serious repercussions on the inhabitants who directly or indirectly depend on the natural environment for their sources of livelihood. Hartley *et al*., (2016), projected that the temperature in West Africa is expected to increase by 1.5°C to 4°C by 2050 especially in the Sahel compared to the Gulf of Guinea. On the precipitation side, changes in rainfall are not as certain as temperature. In the Sahel, July to September by 2050 will be experiencing rainfall in the range of -40% to +20% in the western Sahel, and between -20% and +40% in the central and eastern Sahel. The study points out that there will be a delay in early rainy season (June and July), particularly in the west of the Sahel, and an increase in late rainy season (September and October), particularly in the central and eastern Sahel. The Sahel projected rainfall uncertainty was also buttressed by (Serdeczny *et al*., 2016). This expected future situation will further aggravate the conditions of rural dwellers of Anglophone West Africa who depend on agriculture as their means of sustenance and income generation.

Economic trends in Anglophone West African countries

Fig. 1 shows the Gross Domestic Product (GDP) percentage growth for the past two decades in Anglophone West African countries. It could

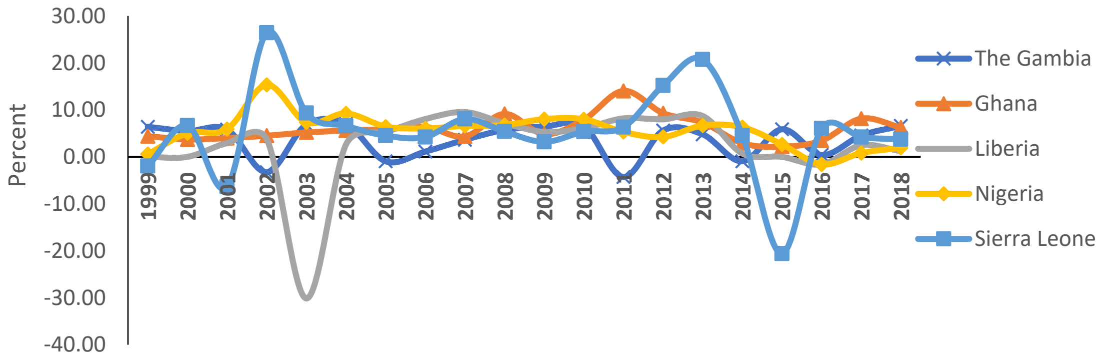

Fig.1: GDP Percentage Growth Rate in Anglophone West Africa (World Bank, 2019)

be observed that these countries experienced fluctuations in growth over the periods as a result of both internal and external economic shocks. Nigeria, the biggest economy in the sub-region, has not registered an impressive growth since 2015. In 2016 the Nigerian economy contracted to -1.6% due to attacks on petroleum facilities in the Niger Delta. As a result, in 2017 the country had a GDP growth of only 0.81%. Liberia and Sierra Leone have in the past decades been recovering from political and economic challenges that plagued them. In 2014 the outbreak of the Ebola disease in West Africa slowed their growth. By 2015 Liberia registered 0% growth and Sierra Leone contracted to -20%. However, both countries saw a rebound in 2017 and 2018. The Gambian economy is showing signs of recovery after the political impasse between December 2016 and mid-January 2017. Ghana's GDP showed signs of buoyancy in 2017 and 2018 (World Bank, 2019). Given the economic vulnerability of Anglophone West African countries, its policymakers should be cognizant of the impact of climate change on growth since a larger number of dwellers of the sub-region depend on nature (climate) for their survival, hence the motivation for the study.

Table 1: Sectorial composition of value-added percentage GDP

Country	Sector (% of GDP)	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Gambia	Agriculture, Forestry and Fishing	25.20	26.22	28.95	18.89	20.34	25.33	22.30	23.55	24.96	23.04
	Manufacturing	5.79	4.98	4.73	5.16	4.89	5.65	6.34	6.11	5.48	4.48
	Services	55.57	54.96	53.09	62.05	60.96	57.12	56.94	53.15	52.85	56.55
Ghana	Agriculture, Forestry and Fishing	29.41	30.99	28.04	23.66	22.13	20.45	20.00	20.25	20.98	19.70
	Manufacturing	7.54	6.77	6.39	6.42	5.66	11.75	11.33	11.37	11.12	10.89
	Services	46.17	47.94	48.18	45.84	47.58	39.15	36.11	39.54	43.09	42.35
Liberia	Agriculture, Forestry and Fishing	65.17	58.04	44.80	44.30	38.80	37.23	35.77	34.37	37.24	37.09
	Manufacturing	2.96	2.81	2.61	2.28	2.12	1.93	2.26	2.14	1.95	1.84
	Services	27.73	36.95	50.20	47.40	44.80	47.01	48.53	53.09	50.34	48.24
Nigeria	Agriculture, Forestry and Fishing	25.28	26.75	23.89	22.23	21.86	20.76	19.99	20.63	20.98	20.85
	Manufacturing	8.17	7.84	6.55	7.17	7.72	8.93	9.64	9.43	8.68	8.74
	Services	48.98	50.98	50.79	49.24	50.19	52.37	54.15	58.12	59.79	55.80
Sierra Leone	Agriculture, Forestry and Fishing	53.65	55.26	52.94	54.59	50.59	47.98	51.79	58.65	58.21	60.28
	Manufacturing	2.44	2.13	2.18	2.25	2.02	1.64	1.53	1.77	1.82	1.96
	Services	35.10	34.60	35.26	35.25	32.56	28.48	29.83	33.87	33.29	32.38

According to the African Development Bank Group (ADBG, 2019), the services sector of West Africa remains the dominant sector in value-added contribution to GDP, accounting for half of the region's GDP in 2018, which was the trend since 2015. Manufacturing accounts for a small share of industry and is limited to light processing of primary products and the production of consumer commodities. The trend in Anglophone West Africa is reflective of the sub-region. In The Gambia, Ghana, Nigeria and Liberia the services sector is the main driver of their economies, whilst for Sierra Leone agriculture is the main driver as indicated in Table 1. Agriculture remains a vital sector contributing on average about 20% of GDP in Anglophone West Africa. In most of these countries, the agriculture sector is the dominant employer; the sector is seen as the most vulnerable to climate change relative to other sectors. The services sector will also be affected by climate change especially the tourism industry which is vital in Anglophone West African countries. Nwamarah *et al*., (2012) point out that climate change will cost Africa about 3% of the continent's GDP valued at US $ 40 billion per annum. Given that Anglophone West African countries are prone to the effects of climate change they will incur a share of this colossal amount which will divert resources needed for development into combating climate change.

Theoretical framework

The theoretical framework of the study follows a dual approach using enumerative and dynamic approaches to study climate change impact on economic growth in Anglophone West Africa. Akram, (2013) elaborate that the enumerative approach mostly focuses on sectorial (agriculture, services etc.) impact of climate change. This approach is done by doing a short run analysis; it ignores intertemporal effects and sectorial linkages. Conversely, the dynamic approach can use different accounting growth models to assess the effects of climate change on growth. Akram, (2013), buttress the assumption of a constant savings rate using the dynamic approach, which has found that climate change has a negative impact on productivity and investment, which in the long run will cause capital stock, consumption per capita and aggregate demand to decline, eventually resulting in unfavorable GDP.

Theoretical model

The production function is used as a model with climate change variables, which forms the baseline for the study. The theoretical underlining for introducing climate change variables into the growth accounting model is for the comprehension of the decomposition of the effects of variations in the weather on economic growth. The basic production function derived by (Dell *et al*., 2008), with some modifications, are demonstrated in Eqs. 1 and 2.

$$Y_{it=e^{\alpha T_{it}}A_{it}L_{it}K_{it}} \tag{1}$$

$$\frac{\Delta A_{it}}{A_{it}} = g_{i+\beta T_{it}} \tag{2}$$

Where Y is GDP, L is measure of population, K is measure of capital, A is technology and can be referred to as labour productivity and T is a measure of climate. Equation 1 illustrates the direct effects of climate on economic growth, e.g. effects on labour productivity. Equation 2 illustrates the indirect (dynamic) effects of climate, e.g. the effects of climate on other variables that indirectly impact GDP. By introducing logs in Eq. 1 and differentiating with respect to time, the Eq. 3 is proposed.

$$g_{it} = g_{i+(\alpha+\beta)T_{it}} + \alpha T_{it-1} \tag{3}$$

Where g_{it} is the growth rate of output. Direct effects of climate change on economic growth are accounted for by α and indirect effects are accounted for by β and g_i is the fixed effects.

Interest in the relationship between the growth of an economy and climate change concerns (pollution, rainfall, temperature, soil degradation, deforestation, erosion etc.) has increased in recent decades. Empirically, several estimation techniques are used to address this important phenomenon. The study used the panel data techniques such as fixed effect, random effect and dynamic panel; Generalized Method of Moments (GMM) and GMM differences. As mentioned previously, the production function incorporates climate change variables and determinants of a country's growth sectors such as agriculture, services and manufacturing into the Cobb-Douglas production function where capital, labour and technology are fixed over time. The economic growth depends on the following variables in the models: population and population growth rate, human capital and human capital growth rate, rainfall and rainfall growth rate, temperature and the rate of growth in temperature. The sectors affected by climate change were regressed by their growth rate. Researchers that used Cobb-Douglas production function include (Hall and Mairesse, 1995), in which they added capital as another factor of production in the model. The paper adopts a model by Mohamed and Sami, (2015). To set out the production function for climate change as Eq. 4.

$$Y = b^{\beta} \ K^{\tau} L^{\delta} CLM^{\varphi} e^{\varepsilon} AW^{\alpha} \tag{4}$$

Where Y is the GDP, A is a given technology which is fixed, CLM is climate change variables (rainfall + temperature), K is capital, L is labour, and W contains population, e is exponential, ε is the idiogratic error term, and τ, δ, φ are parameters which are proportion. Incorporating climate change variables into the model to account for endogenous growth theory developed by (Romer, 1958) in which Romer incorporated human capital into the production function, the same as Eq. 4 using Eq. 5.

$$Y = b^{\beta} \ K^{\tau} L^{\delta} CLM^{\varphi} e^{\varepsilon} AW^{\alpha} \tag{5}$$

Dividing both sides by population to account for per capita terms, the assumption is the production function is constant return to scale i.e. $\tau + \delta + \varphi + \alpha = 1 \leftrightarrow \tau = 1 - \delta - \varphi - \alpha$, using Eq. 6.

$$\frac{Y}{L} = b^{\beta} A \ (\frac{K}{L})^{\tau} \ (\frac{L}{L})^{\delta} \ \ (\frac{CLM}{L})^{\varphi} \ (\frac{W}{L})^{\alpha} \ e^{\varepsilon} \tag{6}$$

Taking the natural logarithm of both sides of the Eq. 7,

$$\log(Y) = \log(b^{\beta} A) + \tau \log(K) + \alpha \log(W) + \varphi \log(CLM) + \varepsilon \log(e) \tag{7}$$

Note: Exponential and log cancel out and let $\log(b^{\beta} A) = \beta_0$, the resultant is as Eq. 8.

$$\log(Y) = \beta_0 + \tau \log(K) + \alpha \log(W) + \varphi \log(CLM) + \varepsilon \tag{8}$$

Transforming equation 8, for the growth model at time t and individual I, Eq. 9 is obtained.

$$g(Y)_{it} = \beta_0 + \tau_{i1} g(K)_{it1} + \alpha_{i2} g(W)_{it2} + \varphi_{i3} CLM_{it3} + a_i + \varepsilon_{it} \tag{9}$$

Taking the first difference or fixed effect transformation or within transformations, Eq. 10 is obtained.

$$g(\bar{Y})_i = \beta_0 + \tau_{i1} g(\bar{K})_i + \alpha_{i2} g(\bar{W})_i + \varphi_{i3} \overline{CLM}_i + a_i + \bar{\varepsilon}_i \tag{10}$$

Arranging the like terms together and subtract Eqs. 9 and 10, Eq. 11 was obtained.

$$\ddot{Y}_{it} = \tau_{it} \ddot{K}_{it} + \alpha_{it} \ddot{W}_{it} + \varphi_{it} \ddot{CLM}_{it} + \ddot{\varepsilon}_{it} \tag{11}$$

This is the fixed effect transformation or within transformation. The unobserved factors in the model disappeared. This suggests that we should estimate the model by pooled Ordinary Lease Square (OLS). The pooled OLS estimator i.e. based on time demeaned variables is called Fixed Effect Estimator or Within Estimator.

Assumption

Cov $(\varepsilon_{it}, CML_{it}) = 0$, *uncorrelated with all the explanatory*

Cov $(\varepsilon_{it}, CML_{it}) \neq 0$, Correlated with all the explanatory variables in the model $\forall FE$

The model takes the form of Eq. 12.

$$Y_t = \beta_0 + \beta_1 POP_t + \beta_2 HC_t + \beta_3 T_t + \beta_4 RF_t + \varepsilon_t \tag{12}$$

In the log-log form we transformed the model as Eqs. 13, 14, 15, 16, 17, 18. 19 and 20.

$$= \text{Model5}(\text{LnGDP}): \ln Y_t = \beta_0 + \beta_1 \ln POP_t + \beta_2 \ln HC_t + \beta_3 \ln T_t + \beta_4 \ln RF_t + \varepsilon_t \tag{13}$$

$$\text{Model4}(\text{Lnclm}): \ln Yclm_t = \beta_0 + \beta_1 \ln HC_t + \beta_2 \ln M_t + \beta_3 \ln Ag_t + \beta_4 \ln S_t + + \varepsilon_t \tag{14}$$

$$Ag_t = \beta_0 + \beta_1 POP_t + \beta_2 HC_t + \beta_3 T_t + \beta_4 RF_t + \varepsilon_t$$

$$\text{Model1}(\text{LnA}):\ \ln Ag_t = \beta_0 + \beta_1 \ln POP_t \tag{15}$$

$$+\beta_2 \ln HC_t + \beta_3 \ln T_t + \beta_4 \ln RF_t + \varepsilon_t \quad (16)$$

$$M_t = \beta_0 + \beta_1 POP_t + \beta_2 HC_t + \beta_3 T_t + \beta_4 RF_t + \varepsilon_t \quad (17)$$

$$\text{Model3}(\text{LnMN}): \ln M_t == \beta_0 + \beta_1 \ln POP_t$$
$$+\beta_2 \ln HC_t + \beta_3 \ln T_t + \beta_4 \ln RF_t + \varepsilon_t \quad (18)$$

$$S_t = \beta_0 + \beta_1 POP_t + \beta_2 HC_t + \beta_3 T_t + \beta_4 RF_t + \varepsilon_t \quad (19)$$

$$\text{Model2}(\text{LnS}): \ln S_t == \beta_0 + \beta_1 \ln POP_t +$$
$$\beta_2 \ln HC_t + \beta_3 \ln T_t + \beta_4 \ln RF_t + \varepsilon_t \quad (20)$$

Where:

$Y_t = GDP\ growth$; $\ln Y_t = GDP\ growth\ rate$; $Ag_t = Agricultural\ Growth$; $\ln Ag_t = Agricultural\ growth\ rate$; $M_t = Manufacturing\ growth$; $\ln M_t = Manufacturing\ growth\ rate$; $S_t = Service\ growth$; $\ln S_t = Service\ growth\ rate$;

Data and data sources

A brief description of the data, the name of the variables and data sources used in the study is presented in Table 2.

RESULTS AND DISCUSSION

Descriptive statistics

Table 3 contains the descriptive statistics of the study. The number of observations fluctuates over time. Panel estimation is used for Anglophone West African countries with comparable CO_2 emission per capita and similar vulnerability to climate change. The study logarithmized the variables to interpret them as elasticity or rate of change over time. The change in the growth rate of the services sector has the highest mean in comparison with the other 2 sectors. This means that the services sector is the highest growing sector and therefore it contributes more to the growth of the observed countries. The second highest growing sector is the agriculture sector, which is just 0.2 lower than the services sector. This is not astonishing since the agriculture and services sectors play a vital role in sustaining the economies of Anglophone West Africa as shown in Table 3.

Correlation

Table 4 contains the correlation results, which illustrates the relationship between variables under investigation. The growth rate of rainfall is positively correlated with the growth rate of the agriculture sector. Thus, in Anglophone West Africa more

Table 2: Data sources

Name of variable	Source	Comment
GDP current ($US)	World Bank, WDI	Current GDP
Human capital (Proxy)	World Bank, WDI	Enrollment in secondary school
Agriculture	World Bank, WDI	Agriculture value added in $US
Manufacturing	World Bank, WDI	Manufacturing value added in $US
Service	World Bank, WDI	Service value added in $US
Temperature	World Bank	Total average temperature
Rainfall	World Bank	Total average rainfall
Climate Change (RF +TEM)		Total climate change variable

WDI= World Development Indicator, RF=Rainfall and TEM=Temperature

Table 3: Descriptive statistics

Variables	Observation	Mean	Standard Deviation
LnH	138	3.178522	0.615652
LnS	182	3.714403	0.356525
LnA	197	3.503667	0.3839572
LnMN	195	1.850174	0.6348749
LnRF	240	4.789997	0.4916931
LNGDp	209	22.0129	2.162124
Lnclm	199	-1.049777	0.252329

LnH=Growth rate of human capita; LnS= Growth rate of Service sector; LnA= Growth rate of agriculture sector; LnMN= Growth rate of manufacturing sector; LnRF = Growth rate of rainfall; LNGDp= Growth rate of GDP; Lnclm= Growth rate of Climate change.

rainfall will result in greater agricultural output thereby increasing the incomes of those dependent on agriculture for their livelihoods. The growth in temperature has a negative impact on the growth rate of rainfall, hence in Anglophone West Africa, as temperature increases rainfall will decrease over time. The growth rate of climate change variables which combines both rainfall and temperature growth rate manifests a negative relationship with the growth of the GDP; therefore, as climate change intensify economic growth in Anglophone West Africa may contract. Thus, there exist an inverse relationship between climate change and growth. The services sector is negatively correlated with growth rate of the agriculture sector, growth rate of rainfall and growth rate of GDP. In Anglophone West Africa as the services sector grows the agriculture sector will experience a decline. As observed earlier in Table 1 the services sector is the dominant sector in almost all the Anglophone West African countries performing better than all the other sectors with the exception of Sierra Leone. The growth rate of the manufacturing sector negatively correlated with the growth rate of rainfall. This implies that if the manufacturing sector is thriving the agriculture sector will not perform.

Panel unit root test

The questions that arise for the panel unit root test (Fisher type unit root test for the coefficients) was based on the Augmented Dickey-Fuller (ADF) tests. Does the data contain a unit root? How to know the confidence level at which to reject the null hypothesis or accept the alternate vice versa. For the growth rate of GDP, does the panel contain a unit root? Given the results, the study failed to reject the null hypothesis, since all the values in this test for the growth rate of GDP are greater than 1%, 5% and 10%. This means there is a unit root in the panel under the given test condition (including panel time, trend and mean). This also answers the second question, because the p-value indicates at which level of significance to reject or accept the null hypothesis. Table 5 contains all the variables with corresponding t-ratios and p-values with drift and trend. There is no unit root for the growth rate of rainfall. The study rejected the null hypothesis at 1%, 5% and 10%. The p-value is smallest and the study rejected the null hypothesis of no unit root in the panel.

Estimation results

The estimated empirical model using the growth rate of agriculture, services, manufacturing, climate change and GDP is illustrated in Table 6. The Hausman test was used for the five equations, which determined the selection of either the fixed effect model or the random effect model. In the Hausman

Table 4: Correlation of variables

Variables	LnH	LnS	LnA	LnMN	LnTM	LnRF	Lnclm
LnA	0.0184	-0.5961	-				
LnTM	0.5035	0.2439	-0.2746	0.371	-		
LnRF	-0.0885	-0.4952	0.4650	-0.41	-0.7733	-	
LNGDp	.6870	-0.2320	-0.3544	0.6279	0.2662	0.0639	-0.1582
Lnclm	-0.2672	0.2159	-0.3227	0.2426	-0.0921	-0.1077	-

Table 5: Panel unit root test (Fish test in the first difference)

Variables	T-Ratios		P-Value	
	Drift	Trend	Drift	Trend
LnH	-3.4077	2.5093	0.0012**	0.9904
LnS	-3.4073	-0.0171	0.0010**	0.4932
LnA	-3.8000	-1.6581	0.0003***	0.0540**
LnMN	-4.1926	-0.3310	0.0001***	0.3715
LnRF	-12.4402	-8.8001	0.0000***	0.0000***
LNGDp	-1.5014	0.8013	0.0720*	0.7853
Lnclm	-6.9391	-1.9464	0.0000***	0.0307**
LnTEM	-4.7105	-11.0444	0.0000***	0.0000***

Computation using Stata 13 *Ntes:* *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 6: Hausman Test Results

Equations	Probability of Chi-square	Chi-square statistic
Model 1 (LnA)	4.22	0.5185
Model 2 (LnS)	58.78	0.000***
Model 3 (LnMN)	-10.13	0.000***
Model 4 (Lnclm)	28.78	0.000***
Model 5 (LnGDP)	-236.66	0.000***

Table 7: Fixed Effect Model Results

Variable	Model 2 (LnS)		Model 3 (LnMN)		Model 4 (Lnclm)		Model 5 (LnGDP)	
	t-ratio Std E S.E.	P-value Coef.	t-ratio S.E.	P-value Coef.	t-ratio S.E.	P-value Coef.	t-ratio S.E.	P-value Coef.
Constant	-0.38 (3.98)	0.707 -1.50	0.99 (8.96)	0.32 8.92	1.93 (1.7)	0.057* 3.28	1.93 (36.2)	0.054* 69.79
LnH	-1.68 (0.05)	0.09* -0.08	0.101 (-2.3)	0.023* -0.23	2.42 (0.1)	0.018* 0.29	9.10 (0.35)	0.000*** 3.17
LnA	-7.70 (0.06)	000*** -0.44	0.13 (-6.9)	0.000***- 0.94	-2.65 (0.2)	0.010* -0.42	-2.65 (0.77)	0.008** -2.04
LnMN	-3.43 (0.04)	0.001*** -0.15			2.25 (0.1)	0.027* 0.18	4.63 (0.39)	0.000*** 1.82
LnRF	1.03 (0.12)	0.31 0.12	-1.11 0.26	0.268 -0.299			1.32 (0.73)	0.185 0.96
LnTEM	1.74 (1.18)	0.09* 2.05	0.13 (2.71)	0.89 0.36			-1.70 (10.4)	0.089* -17.70

Using Stata 13, standard errors between parentheses * p=0.10, ** p=0.05, *** p=0.01

test, the Chi-square test suggests the use of the fixed effect model for the four equations, i.e. models 2 to 5 and one equation for the random effect model, i.e. model 1, meaning the error term is uncorrelated with explanatory variables in the agriculture equation model.

Fixed effect model

The fixed effect model results are contained in Table 7. The results show that the growth of human capital has a negative and significant influence on the growth rate of services and manufacturing while human capital has a positive impact and significant influence on the growth rate of climate change variables. Human capital has a significant and positive relationship with the rate of growth of GDP, thus strengthening the vital role of human capital on the growth and development of Anglophone West Africa. In these countries, the growth rate of agriculture, manufacturing and temperature are all statistically significant on the growth rate of GDP. The variable

Table 8: Random effect model results

Variable	Model 1(LnA)	
Dependent variable LnA	z-ratio S.E.	P-value Coef.
Constant	0.27 (4.73)	0.78 1.30
LnH	-1.98 (0.04)	0.05* -0.09
LnS	-11.02 (0.08)	0.000*** -0.918
LnMN	-10.67 (0.03)	0.000*** -0.37
LnRF	-0.38 (0.09)	0.70 -0.04
LnTEM	1.52 (1,35)	0.129 2.04

Using Stata 13, standard errors between parentheses * p=0.10, ** p=0.05, *** p=0.01

that is not statistically significant but positively impact on growth rate of GDP is the growth rate of rainfall. Hence astonishingly, as observed, agriculture is statistically significant on GDP growth whilst rainfall is insignificant but has a positive impact growth unlike agriculture. Agriculture and rainfall are least impact variables on GDP growth in comparison to human capital. The severe effect of climate change on agricultural was done by (Relly, 1999), (Mendelsohn and Dinar, 1999). In the services sector, rainfall is insignificant but positively impacts on services. Temperature is significant in the services sector model. In the manufacturing sector model both rainfall and temperature are insignificant, negatively and positively impacting the manufacturing sector respectively. Finally, manufacturing, agriculture and human capital growth rates are statistically significant with the growth rate of climate change variable in Anglophone West Africa. The results found out that GDP and agriculture negatively impacted on the growth rate of climate change in Anglophone West Africa. Manufacturing and human capital are significant and have a positive impact on the growth rate of climate change.

Random effect model

The results based on the Hausman test suggest that the random effect model is more appropriate than the fixed effect model in the case of the model growth rate of agriculture. In Table 8, the results reveal that the growth rate of the services sector and the growth rate of the manufacturing sector are highly statistically significant and negatively impact on the growth rate of the agriculture sector. The growth rate of human capital is moderately statistically significant and negatively affects the growth rate of the agriculture sector. As the growth rate of human capital increases by 1%, the growth rate of agriculture reduces approximately by 0.089%. Thus, in Anglophone West Africa's human capital investment has an inverse relationship with agricultural output. This phenomenon is also true for growth rates in both the services and manufacturing sectors. The growth rates of temperature and rainfall are statistically insignificant but associated positively and negatively on the growth rate of the agriculture sector respectively. The growth rate of rainfall has a higher impact on the growth of agriculture in Anglophone West Africa than the impact of temperature. Lack of sufficient rainfall reduces the growth of agriculture. In relative terms, change in rainfall pattern is more harmful to the agriculture sector in comparison to the change in temperature in this region.

CONCLUSION

This research attempts to explain the impact of climate change on economic growth in Anglophone West African countries with similar CO_2 emission per capita and vulnerability to climate change. The results generated shows that the agriculture sector is affected negatively by rainfall. The growth rate of rainfall has a higher impact on the agriculture sector than temperature has on the agriculture sector. In relative terms, manufacturing, agriculture and human capital growth rates are statistically significant with the growth rate of climate change variables in Anglophone West Africa. The growth rate of the agriculture sector, manufacturing sector and temperature are all statistically significant with GDP growth rate whilst the growth rate of the services sector, the agriculture sector and temperature have a negative impact on the growth rate of GDP. The rainfall growth rate is not statistically significant but positively impacts on the growth rate of GDP. The consequences of climate change in Anglophone West African countries have far- reaching problems for its over 240 million inhabitants. In the medium and long run, the region will be affected by the scourge of climate change which will result in sluggish economic performance and growth, underdevelopment, poverty and human misery. Given the foregoing pending consequences in the region, the following policy recommendations are proffered in light of the results generated from the study: 1. Anglophone West African countries should endeavour to legislate laws that will prohibit human activities that will result in decline in rainfall in the region since changes in rainfall patterns have the highest impact on the agriculture sector. 2. Governments in Anglophone West Africa must devise policies that will continuously boost the manufacturing sector since the sector has a positive impact on economic growth in the region. 3. Given that climate change variables negatively impact on agricultural growth as manifested by the results of the study, agricultural experts should proffer solutions to remedy the situation. 4. It is vital for the growth and development of Anglophone West Africa that governments continue to invest in the human capital since there exists a significant and positive relationship between human capital and the rate of growth of GDP. 5. To alleviate poverty in the region Anglophone West Africa governments should formulate policies that will reduce the vulnerability of the agriculture sector to climate change, given the inverse relationship that exists between climate change and the agriculture sector.

AUTHOR CONTRIBUTIONS

C. Belford commenced the process by conceptualizing and formulating the research idea, followed by data collection and cleaning and was also extensively involved in reviewing literature and preparing the manuscript. H. Delin reviewed and edited the final manuscript. E. Ceesay performed the data analysis, results interpretation and discussion. Y. Nasr Ahmed reviewed the analyzed data and helped in the data interpretation. R. Happy Jonga did the proofreading and literature review.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

ADBG	Africa Development Bank Group
ADF	Augmented Dickey-Fuller
CAAS	Chinese Academy of Agricultural Sciences
CIA	Central Intelligence Agency
CLM	Climate Change Variables
CO_2	Carbon dioxide
ECOWAS	Economic Community of West African States
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
IAED	Institute of Agricultural Economics and Development
IsDB	Islamic Development Bank
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Lease Square
SSA	Sub-Saharan Africa
USAID	United States Aid

REFERENCES

Abidoye, B.O.; Odusola, A.F., (2015). Climate change and economic growth in Africa: An econometric analysis. J. Afr. Econ., 24(2): 277-301 **(25 pages).**

ADBG, (2019). West Africa Economic Outlook 2019. African Development Bank Group.

Akram, N., (2013). Is climate change hindering economic growth of Asian economies? Asia-Pac. Dev. J., 19(2): 1-18 **(18 pages).**

Albert, M., (2001). The poverty of Africa's position at the climate change convention negotiations. UCLA

J. Environ. Law and Policy. 19 (1): 10 -20 **(11 pages).**

Bulut, H.; Gürkan, H., (2017). Drought stress due to climate change and effects on plants. (February).CIA, (2019). The World Factbook - Central Intelligence Agency.

Coulibaly, S.K.; Metuge, T.M.; Erbao, C.; Bin, Z.Y., (2017). Climate change effects on cocoa export: case study of Cote D'ivoire. 200 **(1 page).**

Dell, M.; Jones, B.F.; Olken, B.A., (2008). Climate change and economic growth: evidence from the last half century. 23(5): 377-381 **(5 pages).**

Deressa, T.T.; Ringler, C.; Hassan, R.M., (2010). Factors affecting the choices of coping strategies for climate extremes: the case Nile basin of Ethiopia. Univ. of Pretoria.

Fage, J.D.; McCaskie, T. C., (2019). Western Africa | region, Africa | Britannica.com.

Greiner, A. (2004). Anthropogenic climate change in a descriptive growth model. J. Environ. Dev. Econ., 9(5) : 645-662 (**18 pages**).

Hall, B.H.; Mairesse, J., (1995). Exploring the relationship between R & D and productivity in French manufacturing firms. J. Econom., 65(1): 263-293 (**31 pages**).

Hartley, A.; Rowell, D.; Janicot, S.; Guichard, F.; Macadam, I.; Taylor, C.; Parker, D.J., (2016). Africa's climate helping decision-makers make sense of climate information.

Jalloh, A.; Nelson, G.C.; Thomas, T. S.; Zougmoré, R.; Roy-Macauley, H., (2013). West African agriculture and climate change. Int. Food Policy Res. Inst.

James T.; Tingiju Z.; Xinshen D., (2009). The impact of climate variability and change on economic growth in Zambia. IFPRI.

Lavell, A.; Oppenheimer, M.; Diop, C.; Hess, J.; Lempert, R.; Li, J.; Muir-Wood, R.; Myeong, S.; Moser, S.; Takeuchi, K.; Cardona, O.D., (2012). Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In managing the risks of extreme events and disasters to advance climate change adaptation: Special report of the intergovernmental panel on climate change. Cambridge University Press. 25-64 (**40 pages**).

Luderer, G.; Pietzcker, R.C.; Bertram, C.; Kriegler, E.; Meinshausen, M.; Edenhofer, O., (2013). Economic mitigation challenges: How further delay closes the door for achieving climate targets. Environ. Res. Letters, 8(3).

Mehmood-ul-hassan, M.; De Leeuw, J., (2015). Enhancing the quality of African climate change science by investing in peer review capacity.

Mendelsohn, R., (2009). Climate change and economic growth commission on growth and development. Working Paper 60.

Mohamed, A.; Sami, H., (2017). Exploring links between FDI inflows, energy consumption, and economic growth: further evidence from MENA countries. J. Econ. Dev., 42(1): 95-117 **(23 Pages).**

Nwamarah, U.U.; Osman-Elasha, B.; Bahri A.; Theriault, K.; Ngomba, C.M.; Duru, U.; Ahmed, S.M.;

Mafalda, D.; Soto, I.T.; Delahaye, S.; Nalubega, M.; Cunha, J.; Aymen, A.; Musuali, M.; Jehu-Appiah, C., (2012). Solutions for a changing climate: the African development bank's response to impacts in Africa. Afr. Dev. Bank, 8: 1-42 **(42 pages).**

OECD, (2015). The economic consequences of climate change. In the economic consequences of climate change.

Pereira, L., (2017). Climate change impacts on agriculture across Africa. Oxford Res. Encycl. Environ. Sci., 1-35 **(35 pages).**

Romer, A.S., (1958). Tetrapod limbs and early tetrapod life. Evol., 12(3): 365 **(1 page).**

Serdeczny, O.; Adams, S.; Baarsch, F.; Coumou, D.; Robinson, A.; Hare, B.; Schaeffer, M.; Perrette, M.; Reinhardt, J., (2016). Climate change impacts in SSA: from physical changes to their social repercussion. Springer, 15(February), 7-8 **(2 pages).**

Sillah, B.M.S, (2016). Economic impacts of climate change: evidence from OIC member countries. J. Econ. Dev. Stu., 5(4).

Stern, N., (2007). The economics of climate change: the stern review. The economics of climate change: the stern review, 9780521877, 1-692 **(692 pages).**

Sylla, M.B.; Nikiema, P.M.; Gibba, P.; Kebe, I.; Klutse, N.A.B., (2016). Climate change over West Africa: recent trends and future projections. Adaptation to climate change and variability in rural West Africa, (November 2017), 1-244. **(244 pages).**

USAID, (2011). Climate change adaptation in western Africa climate change adaptation in western.

World Bank. (2019). World Development Indicators | Data Bank.

World Bank, (2019). GDP percentage growth rate. World development indicator.

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