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AN ANALYTICAL APPRAISAL OF THE EFFECTS OF ENVIRONMENTAL SECURITY THREAT FACTORS ON HUMAN HEALTH AND PRODUCTIVITY: A CASE OF NIGERIA

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Abstract
Anthropogenic activities impact the functional integrity of the biosphere with the attendant ecosystem degradation and climate change that lead to variability of rainfall affecting agricultural productivity, food security and health of the population. The study was aimed at appraising the consequences of the impacts of environmental security threat factors on rainfall variability and agricultural gross domestic product. Secondary data (1990-2019) were sourced from the Nigerian Meteorological Agency (NIMET), Nigeria Bureau of Statistics (NBS), and World Bank. The Vector Auto Regression and Impulse Response Function specifications were used for the analysis. Results showed that the variables (annual rainfall, agricultural GDP, and carbon emission) are non-stationary in levels but stationary in their first difference. There was no long-run association among the variables. There was a negative relationship among annual rainfall, agricultural GDP and carbon emission. Rainfall variability increased with impulse (shock) and carbon emission. Agricultural GDP responded negatively to carbon emission impulse. Agricultural GDP responded negatively to rainfall variability impulse. Therefore, carbon emission procures rainfall variability, low agricultural GDP, food insecurity, poor health conditions, and low investment and productivity. Relevant government agencies need to restrategize climate change resilience and mitigation programmes in order to reduce the impacts of environmental security threat factors, particularly carbon emission, and to adopt low-carbon economy development model.
Keywords: Agricultural GDP; Carbon emission; human health; Environmental security threat factors

Introduction

Anthropogenic activities give rise to climate change in Nigeria, as evidenced by increase in temperature, variable rainfall, rise in sea level and flooding, drought and desertification, land degradation, more frequent extreme weather events and changes, which affect fresh water resources and loss of biodiversity. These are basic drivers of environment security threats, which result in important ecological and landscape processes that can have irreversible impacts on critical renewable resources, such as water, fiber, food, and clean air (Kepner, 2006; PreventionWeb, 2021). World Health Organization (WHO, 2021a) submits that environmental security threats are induced by climate change, plastic pollution, global emissions, ecosystem damage, human resource depletion and exposure to humans caused by effluents, emissions, wastes, among others. Technological disaster, environmental threat exposure, and the use and inappropriate use of toxic chemicals also impact agricultural output cum GDP.

Olaniyi, Olutimehin and Funmilayo (2019) report that environmental security threat factors have caused increased durations and intensities of rainfall that produced large runoffs and flooding in many places in Nigeria. The flooding of early July 2012 killed 363 people and displaced over 2.1 million people as of 5 November 2012. Beyioku (2016) observes that the flood was responsible for the loss of houses, farms, farm produce, properties and lives. About 5,000 houses and 60 homes were affected in the windstorm that occurred in four states in the south-west region. IRIN Africa 2012) reports that thirty (30) out of Nigeria's 36 states were affected by the floods, which were described as the worst in 40 years, and affected an estimated total of seven million people. National Emergency Management Agency (NEMA, 2015) estimated the damages and losses caused by the floods at N2.6 trillion ($17 million).

Another flooding occurred in Nigeria in 2013 (International Federation of Red Cross (IFRC, 2021). It worsened the misery to a population still recovering from the 2012 fatal floods. Many mud-brick homes collapsed, family belongings were ruined and sources of potable water, including dug wells, were polluted. The floodwaters lasted for 48 hours, affecting Abia, Bauchi, Benue, Jigawa, Kebbi, Kano, Kogi and Zamfara states. The collapse of earth dams in Kaduna and Katsina aggravated the situation, which affected more than 47,000 people.

Reports (Barnett, 2009; Apata, 2011; Prüss-Ustün, van-Deventer, Mudu, Campbell-Lendrum, Vickers, Ivanov, Forastiere, Gumy, Dora, Adair-Rohani and Neira, 2019; CRAWFORD, 2021) show that the impact of environmental security threats or risks can be measured in terms of effects on crop growth, among others. Environmental security threats may result in a 4.5% reduction in GDP by 2050 and critical to loss of livelihoods, increased poverty of over 90 million households engaged in farming. This study appraised the consequences of the impacts of environmental security threat factors on rainfall variability and agricultural GDP in Nigeria.

Environmental security threats or risks include pollution, radiation, noise, land and water degradation and climate change. They are driven by the energy, industry, agriculture, transport, and land use sectors and pose danger to the ecosystem composure and its inter-dependent human component and physical components and systems that maintain life (Prüss-Ustün et al., 2019). In Nigeria, due to environmental security threats, Nigeria's climate has been changing, evident in: increases in temperature; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; affected fresh water resources and loss of biodiversity. The durations and intensities of rainfall have increased, producing large runoffs and flooding in many places in Nigeria (*PreventionWeb*, 2021). Unfortunately, the newness of the discussions on the interrelatedness of environmental security, variable rainfall and agricultural output has yet to produce a unified knowledge. Thus the study investigates the effect of environmental security threats on variable rainfall and agricultural GDP in Nigeria.

Environmental security threat, rainfall and temperature stability in Nigeria

The Anthropocene hypothesis – that humans have impacted "the environment" but also changed the Earth's geology – is being currently tested. Evidence rests upon a broad range of signatures reflecting humanity's significant and increasing modification of Earth systems. This has evolved new markers in physical deposits in the form of the greatest exploitation of novel minerals in the last 2.4 billion years of Earth history. Yet-to-evolve into balance with other Earth systems are the development of ubiquitous materials, such as plastics, climate change and its consequences (e.g. sea level rise), plastic pollution on marine and terrestrial processes, unprecedented rates of biodiversity loss and extinction, global emissions, ecosystem damage and the changing chemical composition of soils, oceans, and the atmosphere (PreventionWeb, 2021).

Considering the entire range of environmental changes, it is clear that the global, large and rapid scale of environmental threat related to the mid-20th century is the anthropogenic climate change described as its main 'yardstick' due to the scale and ubiquity of its impacts that is potentially causing changes in familial status and social hierarchies (Lazrus, 2009), disrupting cosmologically significant human-environment relations (Crate and Nuttall, 2009).

In Nigeria, these environmental changes causing environmental security threats and impacts are obvious. Nigeria's climate has been changing, evident in: increases in temperature; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; affected fresh water resources and loss of biodiversity. The durations and intensities of rainfall have increased, producing large runoffs and flooding in many places in Nigeria (Olaniyi, Olutimehin and Funmilayo, 2019).

Rainfall variation is projected to continue to increase as a result of anthropogenic environmental security threats (PreventionWeb, 2021) with cases of heat wave in Lagos described as one of the most severe heat-waves in 2016 (Olewuike, 2019).

On the other, hand agriculture remains the main stay of the Nigerian economy, in spite of oil. Agriculture employs two-third of the entire working population (FAO, 2018; Onwutuebe, 2019). The sector is plagued with outdated land tenure system that limits access to land (1.8 ha/farming household), reduced irrigation development capacity (cropped land under irrigation less than 1 percent), limited access to credits, low adoption of technologies, expensive farm inputs, limited access to fertilizers, inadequate storage facilities and limited market access. All of these combined, have reduced agricultural productivity (average of 1.2 metric tons of cereals/ha) coupled with high postharvest losses and waste (FAO, 2018).

The sector is also fraught with challenges, as agricultural production is still mainly rain-fed and subject to rainfall vagaries. Farmers find it hard to plan their operations due to unpredictable rainfall patterns (Onyeneke, Nwajiuba, Tegler, Nwajiuba, 2020). Increase in the total amount of rainfall and extreme temperature would have more of a negative effect on staple crops production. However in northern states such as Borno, Yobe, Kaduna, Kano and Sokoto, most crops might benefit economically. Crops, such as millet, melon, sugar cane, that are grown in the north will most likely benefit from extreme temperature (Ajetomobi, 2015).

Rainfall vagaries affects the characteristics and nature of freshwater resources due to rising sea levels and extreme wind events. Increased salinity and shrinking lakes and rivers are also threats to the viability of inland fisheries (Onyeneke, Nwajiuba, Tegler, Nwajiuba, 2020).

Carbon dioxide theory

The carbon dioxide theory of climate change states that, as the amount of carbon dioxide (CO_2) increases, the atmosphere becomes opaque over a larger frequency interval; the outgoing radiation is trapped more effectively near the Earth's surface and the temperature rises. The theory was first proposed in 1861 by Tyndall. The theory has changed dramatically on timescales of decades to centuries in the period 1850 to 1950. In 1896, Svante Arrhenius published an article on the Earth's heat budget as influenced by variations in the concentration of atmospheric CO_2. Variations of atmospheric CO_2 concentration could have a very great effect on the overall heat budget and surface temperature of the planet and might be sufficient to have caused ice ages and interglacial periods. The model relied heavily on the experimental and observational work of others, including Josef Stefan's new law of radiant emission, Samuel P. Langley's measurements of atmospheric transmissivity, Léon Teisserenc de Bort's estimates of cloudiness, Knut Ånsgström's absorption coefficients of water vapour and CO_2, Alexander Buchan's charts of mean monthly temperatures, and A.G. Högbom's estimates of the carbon cycle. T.C. Chamberlin also outlined a carbon dioxide theory of glaciation which proposed that variations of the carbon dioxide content of the atmosphere combined with water vapour feedbacks could account for the advance and retreat of the ice sheets and other geological puzzles.

Analytical framework

Dickey-Fuller and Augumented Dickey-Fuller Test

A series is referred to as stationary if its means and variance are constant overtime and the value of the covariance between the two time periods is time invariant, that is, the statistics do not change over time. It does not mean that the series does not change over time, just that the way it changes does not itself change over time showed that if the dependent variable is a function of a non-stationary process, the regression will produce spurious results (a non-sense regression). The stationarity of a time series can be tested directly with a unit root test. The Dickey-Fuller (DF) and the Augumented Dickey-Fuller (ADF) are both the most frequently used unit root tests. The DF test estimates the following equation:

$$\Delta y_t = c_1 + c_2 t + \omega y_{t-1} + v_t \qquad (1.1)$$

Co-integration

Co-integration has practical economic implications. Many time series are not stationary individually but move together overtime. That is, there are some influences in the series which implies that the two series are bound by some relationship in the long-run. Co-integration variables may deviate from the relationship in the short run but their association would return in the long run. This concept is particularly important in this study where we seek to identify and distinguish those variables that have a long term relationship with the dependent variables.

Since the model in this study is multivariate, there is likelihood of having more than one co-integrating vector. If there is more than one co-integrating relationship, the Engle-Grander approach would produce inconsistent estimates. Thus, in the light of these problems, Johansen methodology is preferable.

VAR

Vector auto-regression (VAR) is a statistical model used to capture the relationship between multiple quantities as they change over time. VAR is a type of stochastic or random process model and they generalize the single-variable (uni-variate) autoregressive model by allowing for multivariate time series. Vector auto-regression (VAR) models are often used in the natural sciences and economics. Vector auto-regression (VAR) model is a dynamic simultaneous equations model. All variables are treated as endogenous variables, each equation has the same explanatory variables, and the lagged explanatory variables are treated as explanatory variables. Vector auto-regression (VAR) model is not only used to overcome complex problem brought by the traditional simultaneous equations models subject to imperfect economic theory but to also overcome complex problem brought by the traditional simultaneous equations models subject to imperfect economic theory, such as the estimation, division, and inference of endogenous variables and exogenous variables. It also studies the dynamic relationship between variables (Doob, 1990; Xiumei, Min, Ming, 2011; Dimitrios, Hall, 2011). So, this work adopted VAR model to examine the two-way influence mechanisms and dynamic association relationship between agricultural growth and carbon emissions.

Materials and Methods

Study area

Nigeria is a federal republic comprising 36 states and the Federal Capital Territory, where the capital, Abuja, is located. Nigeria has a total land area of 923,768 km^2 (356,669 sq mi), making it the world's 32nd largest country. Nigeria lies between latitudes 4° and 14°N and longitudes 2° and 15°E. Its coastline is at least 853 km (530 mi) (Rank Order Area, ROA, 2011). Nigeria had a growing population of 193,392,517 by 2016 (National Bureau of Statistics, 2016).

Nigeria has a varied landscape. The far south is defined by its tropical rainforest climate, where annual rainfall is 60 to 80 inches (1,500 to 2,000 mm) a year. In the south-east stands the Obudu Plateau. Coastal plains are found in both the south-west and the south-east. This forest zone's most southerly portion is defined as “salt water swamp”, also known as a mangrove swamp because of the large amount of mangroves in the area. North of this is fresh water swamp, containing different vegetation from the salt water swamp. North of that is rainforest (Agaga, 2018).

The secondary data (1990-2019) analyzed to achieve the objective of the study were sourced from National Bureau of Statistics (NBS), World Bank and Nigerian Meteorological Agency (NIMET). The data elements collected were agricultural GDP, Nigeria countrywide carbon emission, and Nigeria rainfall figures. Data on agricultural GDP (Appendix 1) were sourced from NBS. Data on annual rainfall were sourced from NIMET (Appendix 2), and data on carbon emission were sourced from World Bank (Appendix 3).

The Vector Auto Regression and Impulse Response Function specifications was used to estimate the effects of environmental security threats on rainfall and agricultural GDP after the data sets were tested for the presence of unit root using the Augmented Dickey-Fuller Analysis (Uni Assignment Centre, UAC, 2020). A forecasted effect of the variables on other variables was done using the variance decomposition of forecast error (Seymen, 2008).

Results and Discussion

Stationarity of variables

To determine the unit root property of the data, the Augumented Dickey Fuller (ADF) test was employed. The results of the test are presented in Table 1.

Table 1: Unit root test results for stationarity of variables

ADF				
		Carbon emission	Rainfall	Agricultural GDP
Level	t-statistic	-6.325	-1.354	7.190
	Critical value (5%)	-2.929	-2.938	-2.972
	Probability	0.0000	0.6042	1.0000
First difference	t-statistic	-11.932**	-4.542**	-3.795**
	Critical value (5%)	-2.975	-1.681	-2.975
	Probability	0.0000	0.0000	0.0030
Decision		I(1)	I(1)	I(1)

**indicates significance at 5 percent level

From Table 1, the ADF (Augmented Dickey Fuller) test results of carbon emission with 5% significance level, critical values of its unit root test is -2.929. T-test value is -6.325, which is less than the corresponding critical value, and thus it can reject that carbon emission series exists unit root, so carbon emission series is stationary series. However, this stationarity is not significant statistically.

From ADF test results of the first difference series of carbon emission with 5% significance level, critical values of its unit root test is -2.975. Its T-test value is -11. 932**, which is smaller than the corresponding critical value, and thus the hypothesis that the time series of carbon emission has unit root is rejected. So, it is stationary series. That means the first difference series of carbon emission is first-order single-integrity.

As shown from ADF test results of rainfall with 5% significance level, rainfall series is non-stationary series. However, from ADF test results of the first difference series of rainfall with 5% significance level, critical values of its unit root test is -1.681. Its T-test value is -4.542** which is smaller than the corresponding critical value. Thus, the hypothesis which the first difference series of rainfall has unit root is rejected. Therefore, it is stationary series. That means the first difference series of rainfall is first-order single integrity.

As seen from ADF test results of agricultural GDP with 5% significance level, critical values of its unit root test is -2.972. T-test statistic is 7.190 which is greater than the corresponding critical value. Thus, we cannot reject that agricultural GDP series exists unit root. So, agricultural GDP series is non-stationary series.

From ADF test results of the first difference series of agricultural GDP with 5% significance level, critical values of its unit root test is -2.975. Its T-test statistic is -3.795** which is smaller than the corresponding critical value, and thus the hypothesis which the first difference series of agricultural GDP has unit root is rejected, so it is stationary series. That means the first difference series of agricultural GDP is first-order single-integrity.

Therefore, given the test results from Table 1 which shows the level test and critical values of carbon emission, rainfall and agricultural GDP we cannot reject unit root existence at 5% significance level. That is, the series are time non-stationary. However for their first difference series, we reject the existence of the unit root of null hypothesis and accept the conclusion that there is no unit root. The first series is therefore stationary and first-order single-integrity.

Cointegration of variables

Table 2: Johansen tests for cointegration

	Trace test	
No. of cointegration	Statistic	5% Critical value
0	9.5696	15.41
1	3.0230	3.76
	Maximum eigen value test	
No. of cointegration	Maximum statistic	
0	6.5466	14.07
1	3.0230	3.76

Cointegration tests can be carried out and also VAR model can be used to describe the impact of the relationship between variables. Cointegration test result is shown in Table 2. When the cointegration hypothesized number is 0, test statistic value of VAR model which consists of carbon emission, rainfall and agricultural GDP is 9.5696, which is smaller than 0.05 critical value, and also 3.0230 < 3.76 therefore, original hypothesis can be accepted, so carbon emission, rainfall and agricultural GDP has no long run relationship among them and a VAR can be estimated. This implies that there is no long run association among Carbon emission, rainfall, and Agricultural GDP; that is, the variables do not move together over time.

Relationship between the variables

This relationship is done in a Vector auto-regression (VAR) framework. University of Northern Iowa, UNI, (2009), Allege (2010); Alege, Osabuohien (2010) and Edoja, Aye, Abu (2016) states that the main strength of the vector auto-regressive (VAR) model lies in the fact that it helps to forecast causality and policy analysis, study variance decomposition of variables in the system, and observe impulse response (IR) mechanism. Tables 3 and 4 show the VAR estimates. The result in Table 3 shows that environmental security threat had negative effect on rainfall, affecting rainfall stability. Also, Table 4 shows that environmental security threats have negative effect on agricultural GDP.

Table 3: VAR estimate of environmental security threat and rainfall

VARIABLES		
	Carbon Emission	Rainfall
Carbon Emission (L1)	-0.112	-0.00135
	(0.184)	(0.00323)
	[-0.61]	[-0.42]
Carbon Emission (L2)	0.00821	-0.00102
	(0.197)	(0.00460)
	[0.04]	[-0.22]
Carbon Emission (L3)	0.0346	-0.00110
	(0.192)	(0.00424)
	[0.18]	[-0.26]
Carbon Emission (L4)	0.0363	0.00108
	(0.183)	(0.00312)
	[0.20]	[0.35]
Rainfall (L1)	-25.20**	-1.123***
	(10.36)	(0.181)
	[-2.43]	[-6.20]
Rainfall (L2)	-15.04	-0.639**
	(11.05)	(0.258)
	[-1.36]	[-2.48]
Rainfall (L3)	12.55	-0.376
	(10.79)	(0.238)
	[1.16]	[-1.58]
Rainfall (L4)	5.927	0.0228
	(10.26)	(0.175)
	[0.58]	[0.13]
Constant	-0.00661	0.445
	(0.0195)	(1.096)
	[-0.34]	[0.41]
R2	0.0538	0.7043
F-statistic	.2204053	9.229452***

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

In Table 3, environmental security threat factor of carbon emission had an overall negative effect on rainfall, affecting rainfall stability. The four lags (L1 to L4) were based on the Akaike Information Criteria and were specified to gain more robust information from the analyzed data after the differencing has been done (National Bureau of Statistics, 2016). In lag one through to lag three, carbon emission had a negative effect on rainfall, (-0.00135) in lag one, (-0.00102) in lag two and (-0.00110) in lag three. This means that for every one percent increase in carbon emission, there is a 0.102% to 0.135% decrease in rainfall.

Table 4: VAR estimate of environmental security threat and Agricultural GDP

VARIABLES		
	Carbon Emission	Agricultural GDP
Carbon Emission L1	-0.122	2.34e-06
	(0.180)	(5.10e-05)
	[-0.68]	[0.05]
Carbon Emission L2	0.0351	1.71e-05
	(0.184)	(5.01e-05)
	[0.19]	[0.34]
Carbon Emission L3	0.0182	-1.04e-05
	(0.202)	(4.44e-05)
	[0.09]	[-0.24]
Carbon Emission L4	0.000539	2.50e-06
	(0.202)	(4.62e-05)
	[0.00]	[0.05]
Agricultural GDP L1	539.6	0.267
	(605.0)	(0.172)
	[0.89]	[1.56]
Agricultural GDP L2	1,695**	0.0716
	(617.6)	(0.169)
	[2.74]	[0.42]
Agricultural GDP L3	-570.1	0.261*
	(678.7)	(0.149)
	[-0.84]	[1.75]
Agricultural GDP L4	-127.2	0.365**
	(680.0)	(0.155)
	[-0.19]	[2.35]
Constant	-0.0139	157.0
	(0.0298)	(100.1)
	[-0.47]	[1.57]
R2	0.0253	0.71
F-statistic	0.1007	9.8435***

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

In Table 4, environmental security threat of carbon emission had an overall negative effect on agricultural GDP. The four lags (L1 to L4) were based on the Akaike Information Criteria and were specified to gain more robust information from the analyzed data after the differencing has been done (National Bureau of Statistics, 2016). In lag three, carbon emission had a negative effect on agricultural GDP (-1.04e-05). This means that for every one percent increase in carbon emission, there is a 0.0000104% decrease in agricultural GDP.

Table 5: VAR estimate of Rainfall and Agricultural GDP

VARIABLES		
	Rainfall	Agricultural GDP
Rainfall L1	-1.066***	0.00523*
	(0.184)	(0.00282)
	[-5.79]	[1.85]
Rainfall L2	-0.375	0.00102
	(0.275)	(0.00274)
	[-1.37]	[0.37]
Rainfall L3	-0.119	-0.00670**
	(0.252)	(0.00266)
	[-0.47]	[-2.52]
Rainfall L4	0.0727	-0.00205
	(0.170)	(0.00285)
	[0.43]	[-0.72]
Agricultural GDP L1	-29.63**	0.140
	(11.81)	(0.181)
	[-2.51]	[0.78]
Agricultural GDP L2	-36.04*	0.108
	(17.60)	(0.175)
	[-2.05]	[0.62]
Agricultural GDP L3	-23.19	0.314*
	(16.14)	(0.170)
	[-1.44]	[1.84]
Agricultural GDP L4	-14.37	0.262
	(10.92)	(0.183)
	[-1.32]	[1.43]
Constant	1.200	256.0**
	(1.742)	(111.7)
	[0.69]	[2.29]
R2	0.7129	0.6953
F-statistic	9.6236***	8.8415***

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

In Table 5, rainfall variability had an overall negative effect on agricultural GDP. The four lags (L1 to L4) were based on the Akaike Information Criteria and were specified to gain more robust information from the analyzed data after the differencing has been done[14]. In lag three to lag four, rainfall variability had a negative effect on agricultural GDP, (-0.00670) in lag three, which is significant at 5%, and (-0.00205) in lag four. This means that for every one percent increase in rainfall variability, there is a 0.2% to 0.6% decrease in agricultural GDP.

Impulse Response Function

An impulse response function shows the response of variables to one standard-deviation shock in itself and in other variables in the model over a particular period. Impulse response function trace out how the endogenous variable of the model respond to changes in the exogenous variables (such as an economy) within a given period (Allege, 2010). Thus, it allows us to trace out how change in one variable impact other endogenous variables.

According to Figure 1, it is observed that when the impulse (shock) is carbon emission, rainfall response was negative. Its decline was between the first and second years, it increased in the second year in the positive side, decreasing again up to the sixth year where it increased and decreased again till the eight year. This indicates that the effect of environmental security threat of carbon emission on rainfall is overall negative. In conclusion, based on the VAR parameter estimates and impulse response function, environmental security threat of carbon emission has negative effect on rainfall. This means that as the environmental security threat of carbon emission increase, there is an overall decrease in rainfall.

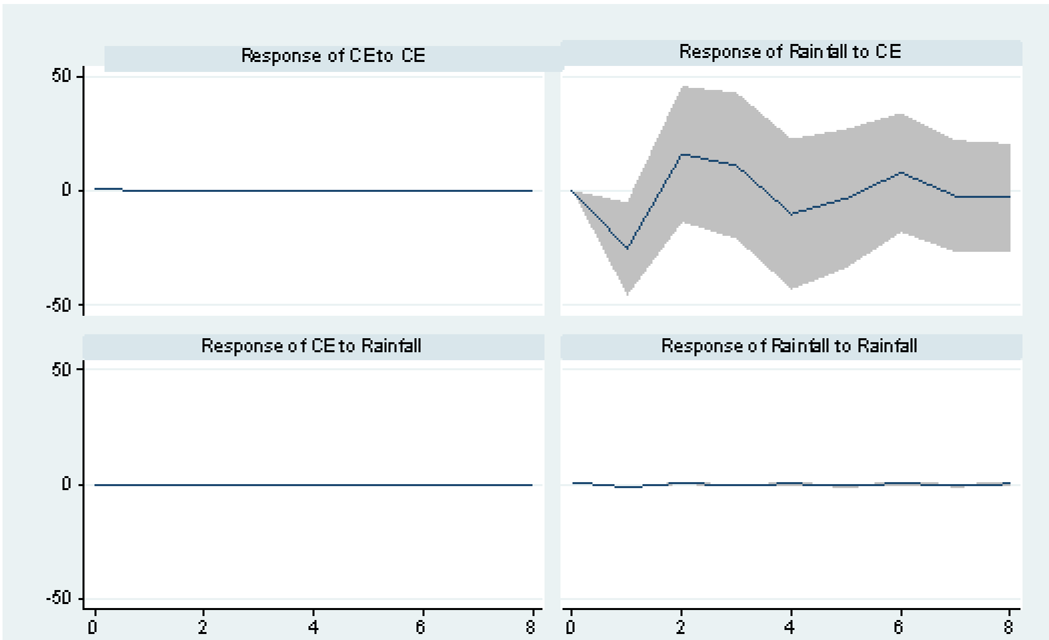

Figure 1: Impulse response of Carbon Emission and Rainfall

According to figure 2, it is observed that when the impulse (shock) is carbon emission, agricultural GDP shock increased on the negative side. It first increased within the first year, then decreased. This indicates that the effect of environmental security threat of carbon emission on agricultural GDP is negative. In conclusion, based on the VAR parameter estimates and impulse response function, environmental security threat of carbon emission has negative effect on agricultural GDP.

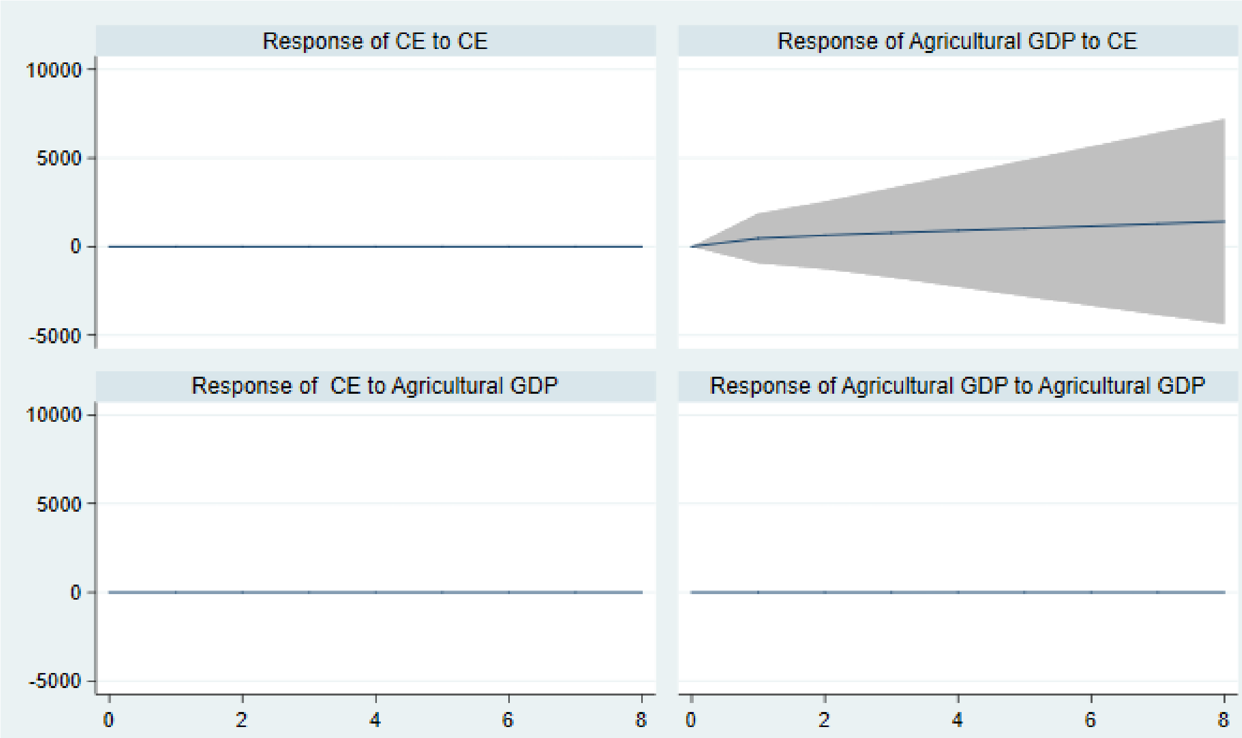

Figure 2: Impulse response of Carbon Emission and Agricultural GDP

According to Figure 3, it is observed that when the impulse (shock) is rainfall, Agricultural GDP increased on the negative side. It first increased within the first year, then decreased in the negative side up to the eight year. This indicates that the effect of rainfall variability on Agricultural GDP is negative. In conclusion, based on the VAR parameter estimates and impulse response function, rainfall variability has negative effect on Agricultural GDP. This means that as rainfall variability increase, there is an overall decrease in Agricultural GDP.

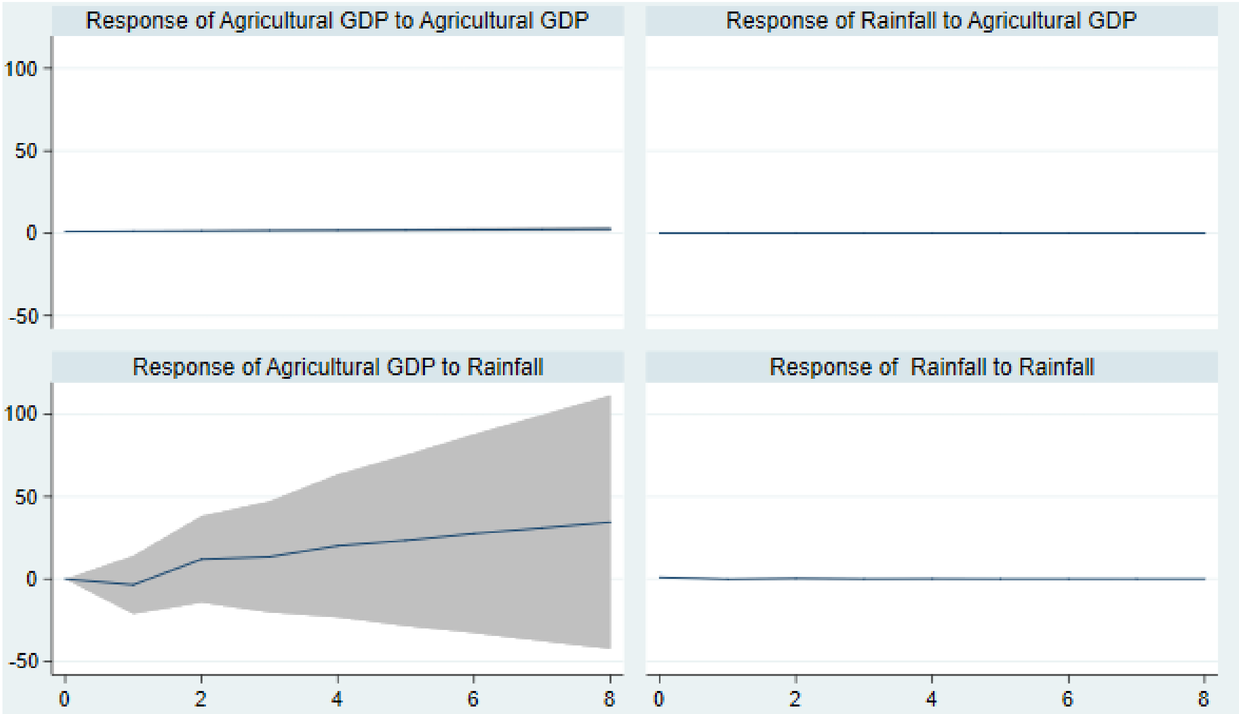

Figure 3: Impulse response of Rainfall and Agricultural GDP

Forecast among the variables

A forecasted effect of the variables on other variables was done using the variance decomposition of forecast error. Variance decomposition provides further evidence of interaction, by quantifying the contribution of the different shocks to the variance in the relevant variables. That is, the impact and contribution of one variable to the changes and/or variations expressed in another variable. In other words, it tells how much of a change in a variable is due to its own and other variable shocks[20]. It shows the percentage error in one variable due to one standard deviation shock of the variable itself (own shocks or variations) and other variables in the system (Allege and Okodua, 2014)). It is majorly used for the purpose of making reasonable forecasts of variables in the model over a specified time period. 10 horizons (10 years) variance decomposition was conducted. The results are presented in Tables 6 to 8.

From Table 6, the forecast error variance decomposition of rainfall with respect to carbon emission shows that in period one, rainfall variation on impact is 3.2 percent. In second and third years, rainfall variation on impact was 12.24 and 13.71 percent but it was up to 19.34 percent in year ten. This implies that about 19% of the changes in rainfall is explained by environmental security threat of carbon emission. These figures are indicative of a modest degree of interaction between Carbon Emission and rainfall and reveals that a change in Carbon Emission results in over 19 percent impact on rainfall variability. That is, the contribution of Carbon Emission to the changes and/or variations expressed in rainfall is over nineteen percent

Table 6: Variance decomposition of Carbon emission

Period	Rainfall
1	0.032287
2	0.122493
3	0.137193
4	0.150046
5	0.19137
6	0.183925
7	0.184417
8	0.183645
9	0.194995
10	0.193353

From Table 7, the forecast error variance decomposition of agricultural GDP with respect to carbon emission shows that in period one, agricultural GDP variation on impact was 8.98 percent. In the second year, agricultural GDP variation on impact was 7.9 percent while it was 21.5 percent in year ten. This implies that changes in agricultural GDP is about 21.5 percent explained by environmental security threat of carbon emission. This is in consonance with studies (Albrecht, François and Schoors, 2002; Kawase, Matsuoka and Fujino, 2006; Narayan and Narayan, 2010: Acaravci and Ozturk, 2010) that have shown that there exists relationship between environmental quality (CO_2 emissions) and growth of the economy.

Table 7: Variance decomposition of Carbon emission

Period	Agricultural GDP
1	0.089828
2	0.079163
3	0.182818
4	0.240414
5	0.24844
6	0.242849
7	0.240812
8	0.221503
9	0.213273
10	0.215226

From Table 8, the forecast error variance decomposition of agricultural GDP with respect to rainfall shows that in period one, agricultural GDP variation on impact is 0.32 percent. In the second year, agricultural GDP variation on impact was 4.68 percent while it was 0.49 percent in year ten. This implies that changes in agricultural GDP is about 4.68 percent explained by rainfall variability. These figures are indicative of an almost average degree of interaction between rainfall and Agricultural GDP and reveals that a change in rainfall results in over 4.68 percent impact on Agricultural GDP. That is, the contribution of variations in rainfall to the changes and/or variations expressed in Agricultural GDP is over 4.68 percent

Table 8: Variance decomposition of Rainfall

Period	Agricultural GDP
1	0.003281
2	0.046849
3	0.035432
4	0.023106
5	0.015537
6	0.011613
7	0.008834
8	0.007017
9	0.005756
10	0.0049

Conclusion

Climate change and carbon emission are some of the environmental security threat factors that result in rainfall variability and the attendant low agricultural GDP, food insecurity, poor health conditions, and low investment and productivity. Other consequences include land and coastal and marine degradation, decreases in primary forest cover, biodiversity losses, and water pollution and scarcity. There is the need for relevant government agencies to re-strategize climate change resilience and mitigation programmes in order to reduce the impacts of environmental security threat factors, particularly carbon emission, and to adopt low-carbon economy development model.

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