

CLIMATE CHANGE: THE ECONOMIC IMPLICAITONS ON DEVELOPING COUNTRIES OF AFRICA

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Abstract

Over the years, there have been increased variations in the Earth (Atmospheric) environment known as climate change. This variation can be ascribed to direct or indirect human activities that alter the atmospheric composition. This study examined the implications of climate change on economic growth in developing countries using some countries in Africa. The data were sourced from the Data bank of the World Bank and estimated using the Vector Auto Regression (VAR) model. Findings revealed that climate change has negative implications on economic growth of the developing countries with 1% GDP growth rate, increased inflation, poor health and mass migration with the consequence of land use crises and insecurity. It was recommended that developing countries should adopt renewable source of energy, the usage of electric vehicle for transport system, cut or prune down the emissions of CO₂ as agreed in Paris 2015.

Keywords: *Africa, Climate change, Carbon dioxide, Economic growth, Environment, Vector Auto Regression*

Introduction

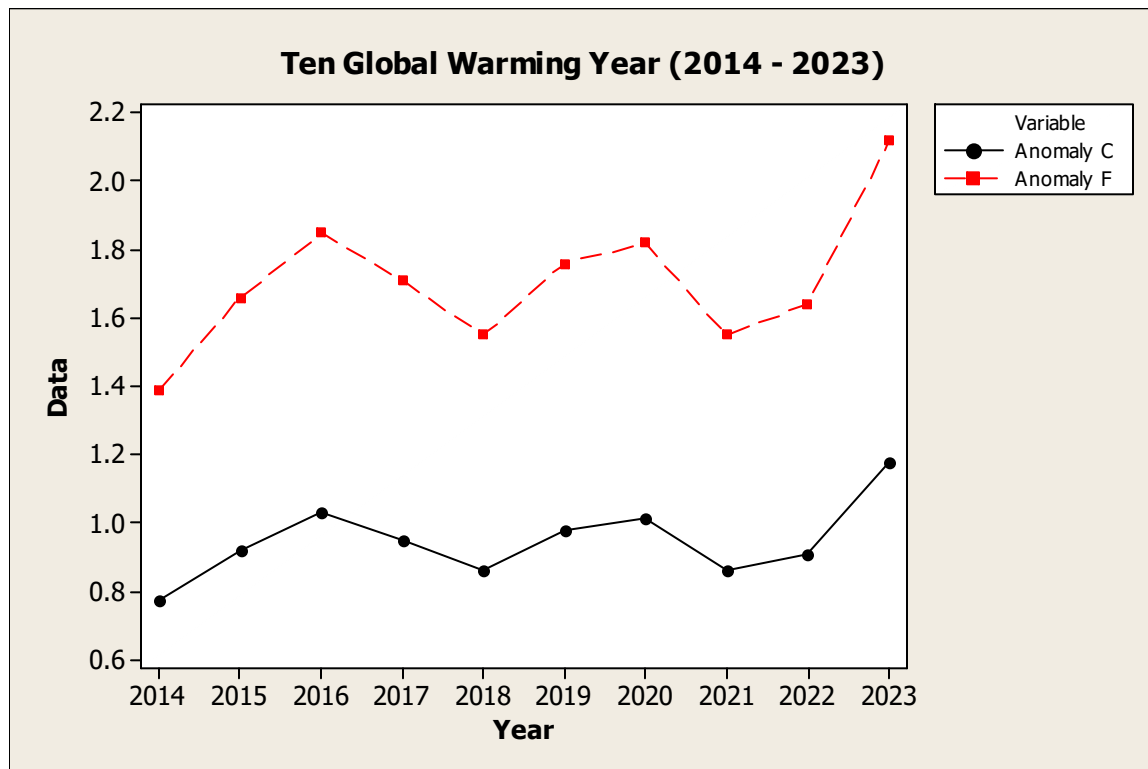
Climate change is one of the consequences of global industrialization. It buttressed the evidence that human activities have released large amount of carbon dioxide (CO₂) into the atmosphere, which had resulted to rising global temperature. Though the scientific and political recognition of this reality has not translated into a commitment to emissions reduction sufficient to stop further global warning, it has become imperative to evaluate the economic implications of climate change and designing policies to address them (Desmet & Rossi-Hansberg, 2024).

Evaluating the impact of climate change on economic growth tends to be complex as one cannot establish the certainty of the degree of future global warning and its subsequent consequences on global activities. Though technological progress has taken the center stage of development, it is also not certain how this will respond or alter the path of climate change across the globe (Wade & Jennings 2016). The impacts of climate change are affecting people in every nation, threatening lives and livelihoods; damaging infrastructures, ecosystems and social systems in communities across the globe. Desmet and Rossi-Hansberg (2024) explored on the issues of climate Change Economics over a period of time and space. They noted that changes in climate have different effects in the northern and southern sphere of the globe. Migration of people and economic activities from the north with abundance of land to the south will reduce the economic cost of

climate change. However, migrants are faced with spatial frictions such as trade, transportation and knowledge that are put in clusters of economic activities. Therefore, the economic cost of climate change is linked with the spatial frictions.

Communities and individual in Africa are particularly vulnerable to these impacts. Climate change can also exacerbate existing pollution problems and environment stressors. All these impacts, portends challenges to the protection of human health and environment. Historically this challenge is increasingly one of the insecurities in an era where stocks whether localized or global in scope, have become more frequent and intense, household communities and government lack the means to protect themselves and the resources they have accumulated (Chandy, 2023).

United Nation Environmental Programme (UNEP) (2023) reported that temperatures have hit new highs, yet the world fails to cut emission more so that the world is heading for temperature rise far above the “Paris Agreement Goals” and unless countries deliver more that they have promised or face global warming of 2.5 to 2.9°C which will be detrimental to human existence. The problem of evaluating the implications of climate change is multifaced and dynamic in nature. The mapping of physical impacts, such as rise in sea levels, extreme weather conditions, or non-linearities in the climate system, is more complex. While anthropogenic temperature change is already affecting our present-day reality, many of its pernicious effects will only be felt in the distant future. Thus, evaluating the implications of warmer temperatures in the far-off future requires dynamic models.



Source: Author's Computation from National Center for Environmental Information

As evident from the National Oceanic Atmospheric Administration (NOAA)'s records (2024), during the global warm phase of ENSO (EL Nino) global temperature tends to be warmer than ENSO – neutral or La Nina years. Despite 2021 and 2022 not ranking among the five warmest

years on record, the global annual temperature increased at an average rate of 0.06°C (0.11°F) per decade since 1950 and more than three times that rate 0.20°C (0.36°F) since 1982 (NOAA, 2024).

During the 2023, each monthly global surface temperature anomaly value ranked among the seven warmest with June through December each ranking as the warmest such month on record. The July global temperature value was likely the warmest of all months on record and the July, August and September temperature anomalies each exceeded 1.0°C (1.84) above the long-term average for the first time on record. The September and mainly value of 1.44°C (2.59°F) was the largest positive monthly global temperature anomaly for any month on record. Global ocean temperatures in 2023 were also noteworthy with nine consecutive months April – December of record warm temperatures. The September Ocean temperature anomaly value ($+1.04^{\circ}\text{C}/+1.87^{\circ}\text{F}$) was warmest of any month on record.

The Northern Hemisphere summer season (June –August) was warmest on record and the Northern Hemisphere autumn (September – November) was not only the warmest such period on record, it also exceeded the previous record from 2015 by 0.39°C (0.70°F) and was the largest positive seasonal anomaly for any season on record in the Northern Hemisphere. The 2023 Northern Hemisphere surface temperature was also warmest on record at $+1.54^{\circ}\text{C}$ ($+2.77^{\circ}\text{F}$) while the Southern Hemisphere had its warmest year on record with temperature that was 0.82°C (1.48°F) above the 20th Century average.

Among the ten warmest ranking period of records from 1850 to 2023, the year 2023 was the warmest year at 1.18°C (2.12°F) above the 20th Century average of 13.9°C . (57.0°F). This value is 0.15°C (0.27°F) more than the previous record set in 2016. The ten warmest years in the record period occurred during the last ten years (2014 – 2023) with 0.77°C (1.39°F) to 1.18°C (2.12°F) respectively. Worthy of note is the fact that year 2005 which was the first year to set a new global temperature record in the 21st Century is now the 12th warmest year on record. The year 2010 had surpassed 2005 at the time, now ranks as the 11th warmest year on record.

The current upward global temperature trend calls for serious concern to forestall adverse detrimental consequences to human existence and survival. Wade and Jennings (2016) investigated the global economic impacts of climate change and reported that as global temperature increase, the rising operating expenses world harm the global economy, suggesting a worst-case annual effect of 1% GDP growth with detrimental impact on the developing countries. As the global climate crises escalate, its divesting impacts on human health and wellbeing will also rise. Changing climate conditions are increasing heat-related illness and deaths; changing the patterns of infectious disease transmission, making deadly disease outbreaks and pandemics more likely; worsening material and child health situations. It exerts significant strains on health systems, simultaneously increasing demand for health services. According to World Bank (2023) warmer climate could lead to at least 21 million additional deaths by 2050 from just five health risks; extreme heat, stunting, diarrhea, malaria and dengue.

As climate change continues to be unabated, it also made the global goal (SDG) of poverty reduction even more challenging to achieve. World Bank (2023), estimates that climate change may push an additional 132 million people (more than half of whom live in Sub-Saharan Africa and South Asia), into extreme poverty by 2030. United Nations Office for Disaster Risk Reduction (UNDRR, 2024) reports that over the past two decades alone, 7,348 natural disasters around the globe have been recorded. The number of people affected has grown to 150 million with an average of 60,000 people every year due to climate change.

Based on the above it is pertinent to ask some questions such as: to what extent has climate change affected economic growth in developing countries? In what way has climate change influence migration in developing countries? This study is thus aimed at investigating the influence of climate change on output and economic growth in developing countries. It also examined the impact of the climate change on agricultural yield in developing countries. In addition, the study explored the influence of climate change on migration in developing countries. This study is expected to proffer policy measures towards the effective reduction of the actions contributing to climate change. It will also contribute to the subject of debate among scholars, analysts and other stake holders across the globe.

Literature Review

Climate change has been identified as one of the major threats to economic development goals and food security. The United Nation (2019) report adopted a new 10 years climate action plan aimed at transforming its operations to achieve a 45% reduction in greenhouse gas emission and sourcing 80% of electricity from renewable energy by 2030. Climate change is expected to have implications in developing countries through its effect on inflation and economic growth. Some theories have been put forward in this regard:

Svante Arrhenius' Theory of Climate Change (1896): In developing a theory to explain the ice ages; Svante Arrhenius used basic principles of physical chemistry to calculate and estimate the extent to which increase in atmospheric carbon dioxide (CO₂) will increase Earth's surface temperature through the greenhouse effect. He concluded that human caused CO₂ emissions from fossil-fuel burning and other combustion processes, are large enough to cause global warming. The conclusion was extensively tested and won a place at the core modern climate science.

$$\Delta f = \alpha \ln \left(\frac{C}{C_0} \right)$$

Where C₀ = the concentration of CO₂ at the beginning (time zero) of the period

C = the CO₂ concentration at the end of the period

ln = the natural logarithm (= log base e(log_e))

Δf = the Augmentation of the temperature.

Empirically, some studies have also examined the issues surrounding climate change. Alagidede, Adu and Frimpong (2014) examined the effect of climate change captured by temperature and precipitation on the sustainable economic growth of Sub-Saharan Africa. Employing panel cointegration techniques, it was revealed that economic performance in Sub-Saharan Africa is significantly reduced by an increase in temperature. An intrinsically non-linear relationship was found between per capita real gross domestic product and the climate factors

Wade and Jennings (2016) also investigated the global economic impacts of climate change and reported that as global temperature increase, the rising operating expenses would harm the global economy, suggesting a worst-case annual effect of 1% GDP growth with detrimental impact on the developing countries. In a very similar study, Stock (2020) in his work on climate change, policy and economic growth made use of temperature, CO₂ emissions and GDP. His finding showed that rising temperatures causes a wide range of climate changes like droughts, hotter days and more powerful rainfalls and storms all which vary locally. He submitted that the principal driver of this warming is anthropogenic carbon dioxide (CO₂) emissions from the combustion of fossil fuels.

In a country study on Nigeria, Ogbuabor and Egwuchukwu (2017) investigated on the impact of climate change on the overall growth of Nigeria. The OLS estimation technique over the period 1981 to 2014. The study revealed that carbon emissions adversely affects economic growth both in the long-run and short-run. Also, forest depletion was found to negatively impact on growth only in the short-run. Private investment and exchange rate were found to hinder economic growth in Nigeria. It was therefore advocated by the study that Nigerian government should evolve and implement policies to curb carbon emissions and forest depletion particularly through the establishment of a National Climate Change Commission.

Employing a quartile regressions Kiley (2021), determined if climate change increases the likelihood of severe economic recession and submitted that warmer temperature has a significant and consistence influence on economic risks across all dimensions. Baig, Chandio, Ozturk, Kimar, Khan, and Salam (2022) in their investigation of asymmetrical dynamic connection between climate change and rice production using time series data and the non-linear autoregressive distributed Lag (NARDL) model and the Granger Causality approach discovered that the mean temperature has a detrimental long-term impact on rice yield while having a positive short-term impact.

Zhao and Liu (2023) examined the transmission channels through which climate change is affecting economic growth. The study was based on a panel framework of 44 countries in Africa, over the period 2000 to 2019 employing a fixed effect and the panel vector autoregression method of estimation with the aim of determining both the short-run and long-run effects of climate change on economic growth. It was revealed that there is an inverted U-shaped effect temperature a channel of climate change on the economic growth of the countries especially countries found at the tropical rainforest and tropical dry climate zones. On the other hand, a U-shaped effect was found for countries in the warm temperate humid regions. Climate change was found to have a significant inverted U-shaped effect on outputs (agricultural and services) in the tropical rainforest and the tropical dry climate zones. While, climate change on the other hand impacted positively on the economic growth of the coastal regions and an insignificant impact on the economic growth of countries in the inland. The tropical rainforest and subtropical humid regions were revealed to have greater adaptability to climate change in the long run, while tropical desert regions suffered more volatility resilience in their response to climate change.

In a more recent study, Zhang, Luo, Zhang and Shu (2024) on the analysis of energy and green technology in China explored the effect of NEDCP on the green technology innovation (GTI) of NEEs. They made use the difference-in-difference-in-differences (DDD) model on a green patent application data for A-share listed NEEs in Shanghai and Shenzhen over the period 2011 to 2019. It was found that NEDCP can substantially increase GTI of NEEs and evident on patent on green invention. This is achieved reducing constraints on external financing and making the market available for the green technology.

Gap in literature

Although there are many empirical literatures on climate change and economic growth/development, their limitation prompted this research. The stagnation in economic growth of the developing countries particularly the Sub-Sahara Africa due to climate change has not been unraveled. The consequent effects of migration resulting from climate change has not been measured hence this work to cover this gap.

Methodology

Estimation method

This study employed the Vector Autoregressive (VAR) model in the analysis building on the study of Zhao and Liu (2023). The method focuses on deriving a good statistical representation of the interactions between variables and the data determine the model. model is mainly used for structural analysis and forecasting. A Vector Autoregression (VAR) model was utilized. It is an ordinary least square (OLS) based model which is applicable for both non-stationary time series as well as for times series with mixed order of integration. This model takes sufficient numbers of lags to capture the data generating process in a general -to-specific modeling framework. A process y_t is said to be a vector autoregressive process of order denoted by VAR(p) if it satisfies the equation

$$y_t = v + A_1 y_{t-1} + \dots + A_p y_{t-p} + \mu_t, t = 0, \pm 1, \pm 2 \dots, \mu_t \sim N(0, \sigma^2) \quad (1)$$

Where $y_t = (y_{1t} \dots, y_{kt})$ is a $(k \times 1)$ random vector, the A_1 are fixed $(k \times k)$ coefficient matrices, $v_t = (v_{1t} \dots, v_{kt})$ is a fixed vector of intercept terms allowing for the possibility of a non-zero mean, $E(y_t)$ Finally $\mu_t = (\mu_{1t} \dots, \mu_{kt})$ is a -dimensional white noise or innovation process, that is,

$$\begin{aligned} E(y_t) &= 0 \\ E(\mu_t \mu_t^1) &= \Sigma_u \\ E(\mu_t \mu_t^1) &= 0 \text{ for all } t \neq s \end{aligned}$$

The covariance matrix is assumed to be non-singular, if not otherwise stated.

For $P = 1$, VAR(1) model:

$$y_t = v + A_1 y_{t-1} + \mu_t \quad (2)$$

The approach it is based on a structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. Where y_t is a k vector of endogenous variables, x_t is a vector of exogenous variables, $A_1 \dots A_p$ and B are matrices of coefficients to be estimated, and is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

$$\begin{aligned} GDP_t &= a_{01} + \sum_{i=1}^p a_{1i} GDP_{t-1} + \sum_{i=1}^q a_{2i} CO2EM_{t-1} + \sum_{i=1}^q a_{3i} AGRICME_{t-1} + \\ &\quad + \sum_{i=1}^q a_{4i} INF_{t-1} + \sum_{i=1}^q a_{5i} MIG_{t-1} + \varepsilon_t \\ CO2EM_t &= a_{02} + \sum_{i=1}^p a_{1i} CO2EM_{t-1} + \sum_{i=1}^q a_{2i} GDP_{t-1} + \sum_{i=1}^q a_{3i} AGRICME_{t-1} + \\ &\quad + \sum_{i=1}^q a_{4i} INF_{t-1} + \sum_{i=1}^q a_{4i} MIG_{t-1} + \varepsilon_t \\ INF_t &= a_{03} + \sum_{i=1}^p a_{1i} INF_{t-1} + \sum_{i=1}^q a_{2i} GDP_{t-1} + \sum_{i=1}^q a_{3i} AGRICME_{t-1} + \\ &\quad + \sum_{i=1}^q a_{4i} CO2EM_{t-1} + \sum_{i=1}^q a_{4i} MIG_{t-1} + \varepsilon_t \end{aligned}$$

$$\begin{aligned} \text{AGRICME}_t &= a_{04} + \sum_{i=1}^p a_{1i} \text{AGRICME}_{t-1} + \sum_{i=1}^q a_{2i} \text{GDP}_{t-1} + \sum_{i=1}^q a_{3i} \text{CO2EM}_{t-1} + \\ &+ \sum_{i=1}^q a_{4i} \text{INF}_{t-1} + \sum_{i=1}^q a_{4i} \text{MIG}_{t-1} + \varepsilon_t \\ \text{MIG}_t &= a_{04} + \sum_{i=1}^p a_{1i} \text{MIG}_{t-1} + \sum_{i=1}^q a_{2i} \text{GDP}_{t-1} + \sum_{i=1}^q a_{3i} \text{CO2EM}_{t-1} + \\ &+ \sum_{i=1}^q a_{4i} \text{AGRICME}_{t-1} + \sum_{i=1}^q a_{4i} \text{INF}_{t-1} + \varepsilon_t \end{aligned}$$

Data sources

The data on Gross Domestic Product (GDP), carbon dioxide emission (CO2EM), Agricultural Methane Emission (AGRICME), Inflation (INF) and Migration (MIG) of the ten African developing countries (Algeria, Nigeria, Keyan, Botswana, Libera, Burkina Faso, Egypt, Ethiopia, Ghana, Morocco) spanning over the period 2010 to 2020. The data were derived from International Monetary Fund (IMF); International Financial Statistics (IFS) and from Word Bank.

Data Analysis, Result and Discussion

Description analysis

The descriptive analysis of the variables was carried out and result is presented in table 4.1.

Table 4.1 Description of Study Variables

	CO2EM	AGRICME	GDP	INF	MIG
Mean	1454245.	108674.6	1.73E+12	6.342609	95845.42
Median	154654.3	15374.09	2.95E+11	4.524212	34017.00
Maximum	10944686	502192.3	1.47E+13	29.50661	321758.0
Minimum	2094.300	4431.708	1.01E+10	-3.233390	530.0000
Std. Dev.	3090571.	169324.2	3.45E+12	5.083388	108077.5
Skewness	2.320557	1.461663	2.595039	1.332104	0.850187
Kurtosis	6.715226	3.426924	8.580437	6.001831	2.233600
Jarque-Bera	145.7892	36.00340	239.5725	66.44959	14.34940
Probability	0.000000	0.000000	0.000000	0.000000	0.000766
Sum	1.44E+08	10758781	1.71E+14	627.9183	9488697.
Sum Sq. Dev.	9.36E+14	2.81E+12	1.16E+27	2532.401	1.14E+12
Observations	99	99	99	99	99

Source: Author's computation using Eviews 10 on the data

Over the period under consideration, Nigerian real level of economic activities averaged about N1.73 Billion with actual values which ranged from N1.01 Billion to about N1.47 Trillion. Carbon dioxide emission on the average was 1454245 where the highest emission recorded within the period was about 10944686 and the least was 2094.300. Agricultural methane emission was on an average of 108674.6 while the highest value recorded within the period was about 502192.3, and the least was 4431.708. Inflation rate within the period of consideration was on the average of 6.3%, while the highest was 29.5% and the least was 4.5%. Migration on the average was 95845. The highest value recorded within the period was about 321758, while the least was 530.

It was revealed that all the series in the study were positively skewed. The kurtosis analyses which show the degree of peakedness revealed that Gross Domestic Product (GDP), carbon dioxide emission (CO2EM), Agricultural Methane Emission (AGRICME), Inflation (INF) and Migration (MIG) were mesokurtic in nature as their values were approximately three (3) and above. The JaqueBerra test of the normality showed that Gross Domestic Product (GDP), carbon dioxide emission (CO2EM), Agricultural Menthan Emission (AGRICME), Inflation (INF) and Migration (MIG) variable normally distributed.

Unit root test

Table 4.2: Levin, Lin & Chu Unit Root Test

Variable	Levels	P – value	1 st diff	P – value	2 nd diff	P – value	Order of integration
GDP	-1.26008	0.10380.0984	-4.22162	0.0001			1(1)
CO2EMM	-1.29079	0.60300.0001	0.73839	0.7699	-1.85887	0.0315	I(2)
AGRICME	0.26117	0.4938	-8.78345	0.0001			I(1)
INF	-5.47224						I(0)
MIG	-0.01561		-3.15703	0.0008			I(1)

Source: Author’s computation using Eviews 10 on the data

Using the Levin, Lin & Chu test for unit root, the result showed that at 5% level of significance, all the variables were stationary at first difference with the exception of inflation that was stationary at levels and carbon dioxide emission (CO2EM) that was stationary at order 2.

Empirical Analysis and Discussion.

From the VAR result (Appendix 1), the result showed that the past realization of first lag of GDP is associated with 1.95% increase in GDP, while the second lag of GDP is about 0.2% decreased in GDP at average ceteria paribus. Also, the percentage increase in first lag of CO2EM accounted for 0.06% increase in GDP, while the percentage decreased in second lag of CO2EM accounted for about 0.5% decreased in GDP. Moreso, percentage decreased in first lag of AGRICME accounted for 0.54% decreased in GDP, while percentage increases in second lag of AGRICME accounted for about 0.6% increase in GDP. It is also observed that, percentage increase in first lag of INF accounted for about 0.0 2% increase in GDP, while the percentage decreased in second lag of INF accounted for 0.008% decreased in GDP. Also, the percentage decreased in first lag of MIG

accounted for 0.65% decreased in GDP, while percentage increase in second lag of MIG accounted for 0.006% increase in GDP.

The past realization of first lag of CO2EM is associated with about 1% increase in CO2EM, while the second lag of CO2EM is 0.03% increased in CO2EM at average cetera paribus. Also, the percentage increase in first lag of GDP accounted for 0.12% increase in CO2EM, while the percentage decreased in second lag of GDP accounted for 0.12% decreased in CO2EM on average cetera paribus. Percentage increase in first lag of AGRICME accounted for about 0.3% increase in CO2EM, while percentage decrease in second lag of AGRICME accounted for 0.37% decrease in CO2EM. It is also observed that, percentage increase in first lag of INF accounted for 0.02% increase in CO2EM, while the percentage decreased in second lag of INF accounted for 0.002% decreased in CO2EM. Also, the percentage decreased in first lag of MIG accounted for 0.003% decreased in CO2EM, while percentage increase in second lag of MIG accounted for 0.008% increase in CO2EM.

The past realization of first lag of AGRICME is associated with 1.2% increase in AGRICME, while the second lag of AGRICME is 0.2% decreased in AGRICME at average cetera paribus. Also, the percentage decrease in first lag of GDP accounted for 0.05% decrease in AGRICME, while the percentage increase in second lag of GDP accounted for 0.3% decreased in AGRICME on average cetera paribus. Percentage increase in first lag of CO2EM accounted for 0.05% increase in AGRICME, while percentage decrease in second lag of CO2EM accounted for 0.04% decrease in AGRIC. It is also observed that, percentage decrease in first lag of INF accounted for 0.008% decrease in AGRICME, while the percentage increase in second lag of INF accounted for 0.0002% increase in AGRICME. Also, the percentage decreased in first lag of MIG accounted for 0.06% decreased in AGRICME, while percentage increase in second lag of MIG accounted for 0.0006% increase in AGRICME.

The past realization of first lag of INF is associated with 0.09% increase in INF, while the second lag of INF is 0.01% decreased in INF at average cetera paribus. Also, the percentage decrease in first lag of GDP accounted for 0.04% decrease in INF, while the percentage increase in second lag of GDP accounted for 0.3% increase in INF on average cetera paribus. Percentage decrease in first lag of CO2EM accounted for 0.8% decrease in INF, while percentage increase in second lag of CO2EM accounted for 0.8% increase in INF. It is also observed that, percentage increase in first lag of AGRICME accounted for 0.7% increase in INF, while the percentage decrease in second lag of AGRICME accounted for 0.6% decrease in INF. Also, the percentage decreased in first lag of MIG accounted for 0.3% decreased in INF, while percentage increase in second lag of MIG accounted for 0.3% increase in INF.

The past realization of first lag of MIG is associated with 0.1% increase in MIG, while the second lag of MIG is 0.12% decreased in MIG at average cetera paribus. Also, the percentage decrease in first lag of GDP accounted for 0.5% decrease in MIG, while the percentage increase in second lag of GDP accounted for 0.5% increase in MIG on average cetera paribus. Percentage decrease in first lag of CO2EM accounted for about 2% decrease in MIG, while percentage increase in second lag of CO2EM accounted for about 2% increase in MIG. It is also observed that, percentage increase in first lag of AGRICME accounted for 0.3% increase in MIG, while the percentage decrease in second lag of AGRICME accounted for 0.3% decrease in MIG. Also, the percentage increase in first lag of INF accounted for 0.09% increase in MIG, while percentage decrease in second lag of INF accounted for 0.01% decrease in MIG.

Impulse and Response Graphs

The impulse and response graph (Appendix II) shows that, increasing in CO2EM will result in GDP to increase. This is however contrary to the study of Ogbuabor and Egwuchukwu (2017) Adu and Frimpong (2014) that found that climate change reduces economic growth for Nigeria and SSA. For AGRICME and GDP, steady increase in AGRICME resulting in steady increase in GDP. For INF and GDP, as INF increases at the first quarters, it causes an increased in GDP, after sometimes it decreases and later became steady in the remaining periods. For MIG and GDP, the behaviour of the plot shows a similar pattern of what was observed in MIG and GDP plot.

The impulse and response graph of CO2EM and AGRICME showed that increasing in AGRICME will result in CO2EM to increase. For CO2EM and INF, decrease in INF will result in decrease of CO2EM. For CO2EM and MIG, the graph depicts that, increase in MIG will result in an increase of CO2EM. From the impulse and response graph of AGRICME and INF, it is observed that, decreasing in INF will result in AGRICME to decrease. For AGRICME and MIG, decrease in MIG will result in a decrease of AGRICME while for CO2EM and MIG, the graph depicts that, increase in MIG will result in an increase in CO2EM. For INF and MIG, as MIG increases at the first quarters, it causes an increased in INF, after sometimes it decreases and later became steady in the remaining periods.

Table 4.3: Variance Decomposition Table

Variance Decomposition of GDP:							
Period	S.E.	GDP	CO2EM	AGRICME	INF	MIG	
1	1.70E+11	100.0000	0.000000	0.000000	0.000000	0.000000	
2	2.66E+11	97.90043	0.574515	0.913372	0.032680	0.579007	
3	3.43E+11	96.52908	1.324133	1.026620	0.182525	0.937640	
4	4.08E+11	95.45149	2.020856	1.256004	0.247543	1.024107	
5	4.66E+11	94.63137	2.762225	1.316397	0.278161	1.011844	
Variance Decomposition of CO2EM:							
Period	S.E.	GDP	CO2EM	AGRICME	INF	MIG	
1	75798.70	23.91735	76.08265	0.000000	0.000000	0.000000	
2	124791.7	21.11121	77.50621	1.381486	8.74E-05	0.000999	
3	165590.5	20.45403	78.26184	1.227413	0.040675	0.016044	
4	200488.7	20.12145	78.36367	1.253496	0.240513	0.020868	
5	231758.0	20.09138	78.21251	1.145433	0.521148	0.029532	

Variance
 Decomposition of
 AGRICME:

Period	S.E.	GDP	CO2EM	AGRICME	INF	MIG
1	1790.362	3.645041	4.059672	92.29529	0.000000	0.000000
2	2347.730	11.79441	10.36831	73.98425	1.293707	2.559325
3	3022.715	13.74743	10.47066	70.82674	1.036824	3.918344
4	3544.420	16.86306	10.95947	64.98612	0.928656	6.262696
5	4071.334	18.69963	10.47448	61.86399	0.719190	8.242708

Variance
 Decomposition of
 INF:

Period	S.E.	GDP	CO2EM	AGRICME	INF	MIG
1	3.346023	2.033778	1.485463	3.783695	92.69706	0.000000
2	4.217479	3.600332	1.737551	7.078867	87.52198	0.061269
3	4.615040	4.587266	1.619018	6.989978	86.74171	0.062032
4	4.815425	4.952735	1.527446	7.355927	86.03664	0.127254
5	4.924365	5.154371	1.460616	7.340109	85.68759	0.357316

Variance
 Decomposition of
 MIG:

Period	S.E.	GDP	CO2EM	AGRICME	INF	MIG
1	16131.29	0.081497	0.142001	0.018871	1.343574	98.41406
2	24168.92	0.065343	0.726006	0.029042	1.725583	97.45403
3	30391.08	0.044622	0.958372	0.034154	3.359382	95.60347
4	35599.45	0.036161	1.017032	0.082817	5.377964	93.48603
5	40179.16	0.044632	1.005440	0.159085	7.358730	91.43211

Cholesky Ordering:
 GDP CO2EM
 AGRICME INF MIG

Source: Author's computation using Eviews 10 on the data

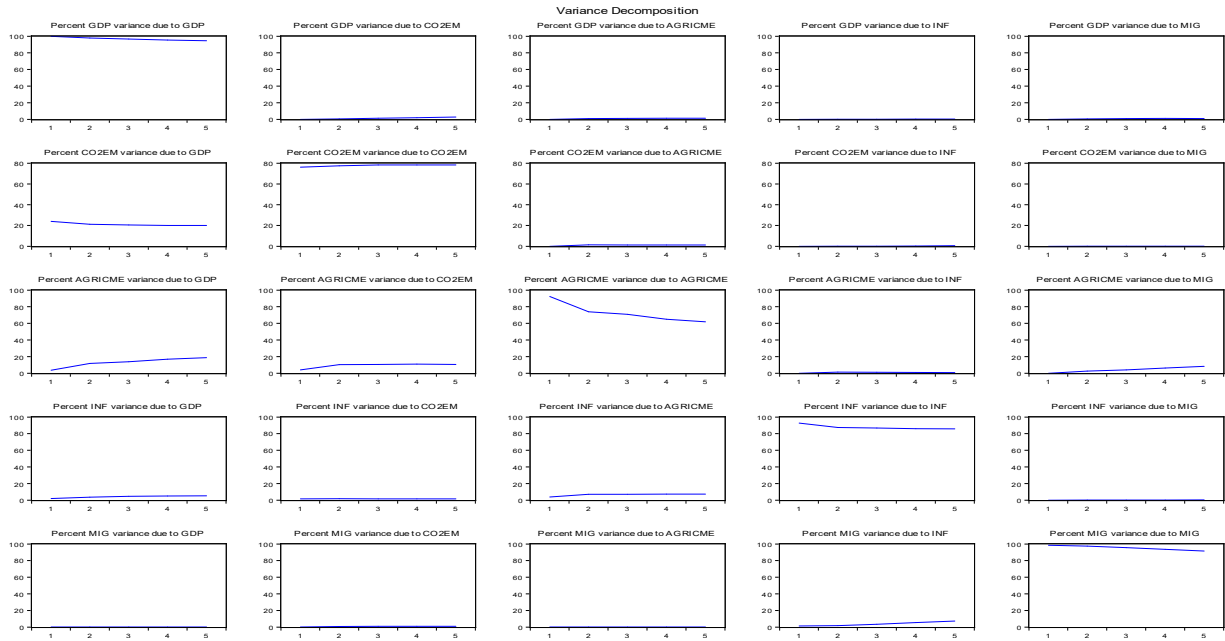


Fig. 4.1: Variance Decomposition Graph

Table 4.3 and Fig. 4.1 showed the variance decompositions of the variables in the short run and long run periods. The periods of forecast of the error variances are divided into short period (1-2) periods and long run periods (3-5) periods. In the short run, looking at year one, 100% of forecast error variance in GDP is explain by the variable itself. Other variables in the model do not have any strong influence on GDP. In that case, those variables have strong exogenous impact. Exogenous in the sense that, they do not influence GDP in the short run. Even looking at year 2, carbon dioxide emission, Agricultural Methane Emission, Inflation and Migration are barely 4%. Again, they exhibit strong erogeneity. Therefore, they have weak influence in predicting GDP. In the long run, 78.2% of the forecast error variance is explained by GDP itself. GDP is showing a strong influence right from the short run into the future. Looking at carbon dioxide emission on GDP is rising over the years. But in overall it is weak in influencing GDP.

It is also observed that, in the short run, looking at year one, 76% of forecast error variance in carbon dioxide emission is explain by the variable itself. Other variables in the model do not have any strong influence on carbon dioxide emission, except GDP. In that case, those variables have strong exogenous impact; they do not influence carbon dioxide emission in the short run. In the long run, 78.2% of the forecast error variance is explained by carbon dioxide emission itself. carbon dioxide emission shows a strong influence right from the short run into the long period.

Furthermore, in the short run, looking at year one, 92.3% of forecast error variance in Agricultural Methane Emission is explain by the variable itself. Other variables in the model do not have any strong influence on carbon dioxide emission, except GD and carbon dioxide emission that shows some level of influence in Agricultural Methane Emission. In that case, those variables (Inflation and Migration) have strong exogenous impact; they do not influence Agricultural Methane Emission in the short run. In the long run, 61.9% of the forecast error variance is explained by Agricultural Methane Emission itself. Agricultural Methane Emission shows a strong influence right from the short run into the long period.

Again, in the short run, looking at year one, 92.7% of forecast error variance in inflation is explain by the variable itself. Other variables in the model do not have any strong influence on inflation.

In that case, those variables have strong exogenous impact. This shows that they do not influence inflation in the short run. Even looking at year 2, carbon dioxide emission, Agricultural Methane Emission, Inflation and Migration are barely 13%. Again, they exhibit strong ergogeneity. Therefore, they have weak influence in predicting inflation. In the long run, 85.7% of the forecast error variance is explained by inflation itself. Inflation shows a strong influence right from the short run into the future.

Lastly, in the short run, looking at year one, 98.4% of forecast error variance in Migration is explain by the variable itself. Other variables in the model do not have any strong influence on Migration. In that case, those variables have strong exogenous impact. This shows that they do not influence Migration in the short run. Even looking at year 2, carbon dioxide emission, Agricultural Methane Emission, Inflation and Migration are barely 4%. Again, they exhibit strong ergogeneity. Therefore, they have weak influence in predicting Migration. In the long run, 91.4% of the forecast error variance is explained by Migration itself. Migration shows a strong influence right from the short run into the future.

Summary of Findings, Recommendations and Conclusion

Summary of Findings

The study examined the implication of climate change on economic growth in developing countries. The study employed the Vector Autoregression (VAR) model. Based on the findings, we can infer that the global economic impacts of climate change cause global temperature increase, the rising operating expenses world harm the global economy, suggesting a worst-case annual effect of 1% GDP growth with detrimental impact on the developing countries. The 1% GDP growth represents a low economic growth in sub-Sahara Africa due to climate change is a responsible factor for the low or slow economic growth as the agriculture yields cannot turn out adequate raw materials required for mass or large-scale production.

This is in line with the study of Stock (2020), on climate change, policy and economic growth. The study made use of temperature, CO₂ emissions and GDP and found that rising temperatures caused a wide range of climate changes like droughts, hotter days and more powerful rainfalls and storms all which vary locally. He submitted that the principal driver of this warming is anthropogenic carbon dioxide (CO₂) emissions from the combustion of fossil fuels.

The findings of this study also submitted that global warming has detrimental effect on agricultural yields in the developing countries as the available land for cultivation is easily worn out of fertility making it difficult for crops to thrive in the scorching environment. This is in line with Baig et al (2022) in their investigation of asymmetrical dynamic connection between climate change and rice production using time series data and the non-linear auto regressive distributed Lag (NARDL) model and the Granger Causality approach where that discovered that the mean temperature has a detrimental long-term impact on rice yield while having a positive share term impact.

Climate change also had negative effect on migration as the people in the adversely affected areas decide to relocate to other areas less affected for survival and habitation. This migration has compounded land use crises and insecurity in Sub-Sahara Africa. Further inference from this study revealed that Global warming will influence economic growth via damage to property and infrastructures, high cost of productivity, mass Migration and global insecurity as also found by Wade and Jennings, (2016).

Inflation is likely to rise as shortages emerges particularly in agricultural produce. Agricultural yields are sensitive to climatic conditions and as the climate ever get distorted more frequent drought may jeopardize crop yield and further culminate to food shortage crises and then trigger increase in price.

Recommendations

Based on the findings, the following are recommendations are made:

- i. The study advocates for the switch to renewable sources of energy particularly given the impact of the climate on agricultural output and hence affecting economic development.
- ii. The study also recommends the policy measures of the use of non-organic agricultural products. This will enhance the productivity of the agricultural sector and thus reduce the high rate of migration in Africa countries.
- iii. The study further recommends placing an upper limit on the amount of carbon dioxide that should be permitted for emission into the atmosphere within a given timeframe.
- iv. The stabilization of global temperature near its current level is also recommended for the elimination of all emissions of heat-trapping gases or, equivalently, achieving a carbon-neutral society in which people remove as much carbon from the atmosphere as they emit. Achieving this goal will require substantial societal changes in energy technologies and infrastructure that go beyond the collective actions of individuals and households to reduce emissions.
- v. Inflation was found from the study to have a decreasing impact on economic growth. Hence, the study recommends that governments in Africa countries put in place inflation control to reduce the impact of inflation on economic growth.

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APPENDIX I

Vector Autoregression Estimates

Date: 12/05/23 Time: 09:57

Sample (adjusted): 2012 2020

Included observations: 75 after adjustments

Standard errors in () & t-statistics in []

	LNGDP	LNCO2EM	LNAGRICME	LNINF	LNMIG
LNGDP(-1)	1.119548 (0.12551) [8.91998]	0.128804 (0.06146) [2.09581]	-0.046884 (0.06561) [-0.71457]	-0.402880 (0.51104) [-0.78836]	-0.506950 (0.48651) [-1.04202]
LNGDP(-2)	-0.166905 (0.12237) [-1.36396]	-0.139938 (0.05992) [-2.33543]	0.031502 (0.06397) [0.49246]	0.290078 (0.49824) [0.58220]	0.469140 (0.47433) [0.98906]
LNCO2EM(-1)	0.061166 (0.28209) [0.21683]	0.963041 (0.13813) [6.97191]	0.047301 (0.14747) [0.32076]	-0.821413 (1.14859) [-0.71515]	-1.939514 (1.09347) [-1.77373]
LNCO2EM(-2)	-0.046367 (0.28039) [-0.16537]	0.027365 (0.13730) [0.19931]	-0.040372 (0.14657) [-0.27544]	0.838332 (1.14164) [0.73432]	1.980450 (1.08685) [1.82219]
LNAGRICME(-1)	-0.543752 (0.23233) [-2.34039]	0.270741 (0.11377) [2.37981]	1.183896 (0.12145) [9.74772]	0.703410 (0.94599) [0.74357]	0.304279 (0.90058) [0.33787]
LNAGRICME(-2)	0.590401 (0.23736) [2.48742]	-0.259652 (0.11622) [-2.23405]	-0.170980 (0.12408) [-1.37800]	-0.630113 (0.96643) [-0.65200]	-0.251028 (0.92005) [-0.27284]
LNINF(-1)	0.014499 (0.03392) [0.42747]	0.010828 (0.01661) [0.65194]	-0.008005 (0.01773) [-0.45148]	0.668581 (0.13811) [4.84104]	0.087503 (0.13148) [0.66553]
LNINF(-2)	-0.007673 (0.03202) [-0.23966]	-0.019716 (0.01568) [-1.25751]	0.000212 (0.01674) [0.01265]	0.134825 (0.13037) [1.03419]	-0.013779 (0.12411) [-0.11102]
LNLMIG(-1)	-0.006511 (0.02151) [-0.30270]	-0.002850 (0.01053) [-0.27054]	-0.005943 (0.01125) [-0.52853]	-0.275041 (0.08759) [-3.14019]	1.085593 (0.08338) [13.0192]

LNMI(-2)	0.005705 (0.02021) [0.28229]	0.008408 (0.00990) [0.84969]	0.000621 (0.01056) [0.05880]	0.266770 (0.08228) [3.24218]	-0.137626 (0.07833) [-1.75696]
C	0.625405 (0.36699) [1.70416]	0.278889 (0.17970) [1.55197]	0.262952 (0.19184) [1.37066]	2.518273 (1.49425) [1.68531]	0.523098 (1.42253) [0.36772]
R-squared	0.996740	0.999463	0.999096	0.737720	0.963907
Adj. R-squared	0.996230	0.999379	0.998955	0.696739	0.958267
Sum sq. resids	0.694018	0.166407	0.189657	11.50577	10.42788
S.E. equation	0.104135	0.050991	0.054437	0.424002	0.403653
F-statistic	1956.574	11909.24	7075.467	18.00144	170.9189
Log likelihood	69.18254	122.7349	117.8307	-36.12140	-32.43269
Akaike AIC	-1.551534	-2.979599	-2.848818	1.256571	1.158205
Schwarz SC	-1.211636	-2.639700	-2.508920	1.596469	1.498103
Mean dependent	26.93347	12.40604	10.35311	1.634130	10.36486
S.D. dependent	1.696043	2.046153	1.684038	0.769945	1.975921
Determinant resid covariance (dof adj.)	2.00E-09				
Determinant resid covariance	9.06E-10				
Log likelihood	248.7321				
Akaike information criterion	-5.166190				
Schwarz criterion	-3.466699				
Number of coefficients	55				

APPENDIX III

Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 S.E.

