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The Impact of Climate Change on Actual Output in Some Selected Countries in Africa: A Specific Focus on Greenhouse Gas Emission

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ABSTRACT

This study seeks to investigate how climate change affects actual output in African countries, using greenhouse gas emission as a case study. This paper uses the actual output of Nigeria, Ghana, Liberia, The Gambia, Cabo Verde, and Sierra Leone for the analysis. Climate change is proxied by greenhouse gas emission, which are extracted from the International Monetary Fund (IMF) database, for the period, 1980 to 2022. Descriptive statistics, unit root, and panel System Generalized Method of Moments 1(SGMM1) are estimated, and the result shows that agricultural greenhouse gas emission reduces the output of the selected African Countries, while other greenhouse gases such as building and other sector's greenhouse gas emission, energy industries greenhouse gas emissions, mineral industry greenhouse gas emission and road transport greenhouse gas emission increase output. For actual output to increase, the paper suggests policy remedies such as sustainable farming practices and adoption of climate-smart technologies.

KEYWORDS

Climate change; Actual output; Greenhouse Gas; SGMM; Africa

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1. Introduction

Climate change represents one of the most pressing global challenges of our time, with far-reaching impacts across various sectors of society and the economy. In Africa, a continent already vulnerable to climatic extremes and environmental degradation, the effects of climate change pose severe risks to economic stability and growth. Among the myriad of factors influencing economic performance, greenhouse gas (GHG) emissions have emerged as a critical concern due to their role in exacerbating climate change and its associated impacts on actual output. Tadesse (2010) believes that despite Africa being among the least polluting continents, experts predict that African countries will be mostly and negatively impacted by climate change, in terms of their efforts to achieve food and water security, sustainable development, and political and economic stability. Africa is not immuned to climate change due to its reliance on agriculture, which involves mechanization and deforestation, as well as its limited capacity to adapt to climatic shocks. The continent is expected to experience severe consequences from climate change, primarily because of its heavy dependence on agriculture, which makes it highly vulnerable to unfavorable direct effects (Collier, Conway, and Venables, 2008).

The relationship between climate change and economic development requires deeper exploration to understand how various climate-related impacts affect economic outcomes. Nkomo, Nyong, and Kulindwa (2006) highlight that Africa's vulnerability to climate change is closely tied to its adaptability, which depends on factors such as technological advancements, education, access to credit, and overall economic development. While industrialized nations grapple with the consequences of their industrial activities contributing to climate change, African countries face similar challenges driven by agricultural practices that contribute significantly to GHG emissions. Tongwane and Moeletsi (2018) emphasize that Africa's agricultural sector is among the fastest-growing contributors to greenhouse gas emissions globally, driven by population growth and rising demand for food.

The motivation for this study stems from the urgent need to address the critical gap in understanding the link between climate change and economic output in Africa, with a specific focus on the role of greenhouse gas emissions. Africa's economies are at a pivotal point where climate-induced challenges could derail growth trajectories, exacerbate poverty and deepen socioeconomic inequalities. Addressing this challenge requires a robust analysis of how GHG emissions impact actual output across different sectors and countries. By examining the intricate relationship between these variables, this study seeks to provide insights that can inform evidence-based policies aimed at mitigating the adverse effects of climate change while promoting sustainable economic growth. This research is not only timely but also essential in fostering resilience and adaptive capacity within African economies, ensuring that they can withstand the adverse impacts of a changing climate while pursuing sustainable development objectives.

This study makes a significant contribution to the literature by addressing the critical link between climate change, particularly greenhouse gas (GHG) emissions and actual economic output in Africa. While existing studies have explored the vulnerability of Africa to climate change (e.g., Nkomo, Nyong, and Kulindwa, 2006; Collier, Conway, and Venables, 2008), there remains a research gap regarding the direct and quantifiable impact of GHG emissions on economic performance across sectors and countries within the continent. Unlike previous studies that focus on general climate vulnerability, this paper empirically examines the specific relationship between GHG emissions and actual economic output. By isolating GHG emissions as a critical factor, the research highlights their direct and indirect impacts on economic growth, sectoral output, and overall productivity. The study provides a nuanced analysis across key economic sectors (e.g., agriculture, industry, services) and regions within Africa. This approach allows for a better understanding of how climate-induced GHG emissions differentially affect output, considering Africa's diverse economic and environmental landscape. The research highlights Africa's limited adaptive capacity to climate change, which stems from factors such as low technological adoption, limited access to finance, and dependence on climate-sensitive sectors like agriculture. By identifying these challenges, the study advocates for targeted interventions to build resilience, promote green technologies, and improve adaptive infrastructure. Given the growing global urgency to tackle climate change, this study is particularly timely. Africa's economic trajectories are at a critical juncture, and this research provides actionable insights to mitigate the adverse effects of climate change while fostering sustainable development goals (SDGs).

2. Literature

2.1. Theoretical Literature

The greenhouse effect is a fundamental concept explaining how certain gases (like CO_2, methane, and water vapor) trap heat in the Earth's atmosphere, leading to global warming. This concept is part of broader theories on climate forcing, which examine how different factors (natural and anthropogenic) influence the Earth's climate system. This was propounded by John Tyndall. This study adopts this theory.

2.2. Empirical Literature

Few empirical and conceptual literature have tried looking at the relationship between climate change and output in Africa using greenhouse gases as a case study. We therefore reviewed most empirical literatures related to climate change and output in sections such as regions and in countries. William, Mamma, and Abdulmalik (2019) propose that the lack of economic growth, the region's heavy reliance on natural resources for agricultural production, and its low level of technological advances have made Sub-Saharan Africa (SSA) one of the most vulnerable regions to climate change. They test the impact of global GHG emissions on the economic growth of Sub-Saharan Africa (SSA) and the link between economic growth and GHG emissions in SSA using the Environmental Kuznets hypothesis. Specifically, the study estimates a Vector Autoregressive and an Ordinary Least Square regression using aggregate panel data covering the period, 1970 to 2012. The findings show that while there is a short-term correlation between environmental quality and economic growth, there is no discernible turning point for greenhouse gas emissions. Nkomo, Nyong, and Kulindwa. (2006) are of the view that Africa is among the regions most severely affected by the harmful effects of climate change, although has contributed little to the issue. Due to the dominance of tropical weather patterns, Africa currently experiences a very changeable climate. Tsaurai (2018) investigates how greenhouse gas (GHG) emissions affect economic growth as well as whether GHG and financial development jointly boost economic growth in Southern and Western Africa. Using annual data from 2001 to 2012, the study employs four econometric estimation techniques; fixed and random effects, pooled ordinary least squares (OLS), and dynamic Generalized Methods of Moments (GMM). It is determined that GHG emissions have a non-significant positive (pooled OLS), non-significant negative (fixed and random effects), and significant positive (dynamic GMM) effects on economic growth. Pepijn and Sander (2017) study how climate change affects Africa's rice production. They mimic the effects on rice in rainfed (lowland and upland) and irrigated (dry and rainy season) systems. They also mimic the application of rice cultivars with larger temperature sums as a means of adaptation. They discovered that while more research is required for West Africa on photosynthesis processes at extreme temperatures and on adaptation options like shifting sowing dates, improved water and nutrient management will be necessary for East Africa to fully benefit from the more favourable temperatures and increased CO2 concentrations.

Abunyewah et al. (2023) use survey data from 874 farmers in Ghana's Western North Region to investigate the impact of climate change knowledge, anxiety, and experience on climate adaptation. The instrumental variable regression technique is used to account for endogeneity and provide unbiased estimates. The findings show that farmers' adaptation to climate change is greatly increased when they are more knowledgeable and anxious about it. According to the Government of Ghana (2021), Ghana, along with numerous other similar countries, is currently undertaking measures to mitigate the worst effects of climate change. They are collaborating and forming partnerships with stakeholders to raise awareness and promote sustainable development for sound environmental governance.

According to USAID from the American People, Liberia is susceptible to the effects of climate change and variability, including rising temperatures, more yearly precipitation and an increase in the frequency of heavy precipitation events. The effects of climate change challenge the nation's poor ability to adapt to climate change, partly a result of the negative consequences of the civil war that raged there from 1989 to 2003. Also, The Gambia National Contingency Plan (2022) states that The Gambia is quite vulnerable to natural calamities, especially flooding. Rising sea and river levels are a result of global warming brought on by climate change. The Gambia`s Long-Term Climate-Neutral Development Strategy (2020-2050) postulates that The Gambia, including its historic capital city of Banjul, is among the nation's most vulnerable to the consequences of climate change. However, it makes up less than 0.01% of the world's greenhouse gas emissions.

According to Climate Change & Weather on Cape Verde (2020), Since the 1950s, Cabo Verde has experienced a decline in precipitation along with increased variability, leading to significant changes in native plant life. As a result, farmers have had to adapt by modifying crop types and shifting cultivation to more suitable regions. Droughts have historically taken lives. This indicates that, because of the lack of rainfall, emergency slaughters now occur every few years when the animals have run out of food. Out of 192 countries, Cabo Verde is ranked 76th in terms of preparedness to address the threat posed by climate change and 98th most vulnerable to it globally (ND-GAIN, 2021). Pina (2019) is of the view that the main effects of climate change that Cabo Verde may expect are an increase in sea level, along with temperature and an increased frequency of droughts and natural disasters (particularly flooding and excessive rainfall). However, there is currently no data or comprehensive information available to predict the effects on ecosystems and livelihoods, as well as the areas that will be most impacted. A growing number of individuals are reporting increased drought and flooding, according to Eduonoo (2023). Most people who are aware of climate change believe that living conditions are getting worse. Most people believe that to safeguard Cabo Verde from the threat posed by climate change, more action must be taken by industrialized nations, the government, the business community and regular residents.

Haider (2019) asserts that there are regional differences in the difficulties brought on by climate change. Nigeria has a tropical climate with two distinct precipitation regimes: high precipitation in certain areas of the Southwest and Southeast and low precipitation in the country's north. Rainfall is one of the climate changes that Nigeria is faced with. Increased rainfall durations and intensities have led to significant runoffs and flooding in various parts of Nigeria (Enete IC, 2014). It is anticipated that the variety in rainfall will keep rising. According to a National Action Plan on Gender and Climate Change for Nigeria (2020), Nigeria is currently dealing with major environmental security issues related to climate change, such as landslides, erosion, desertification, droughts and heat waves. These issues put a strain on the country's infrastructure and natural resources, which include land, water and forests. To examine the consequences of rapid climate change on grain production and the human population in Nigeria, Apata (2008) uses a multinomial choice and stochastic simulation model to study the determinants of farm-level climate adaption methods. Over ten years, the model computes the production, consumption and storage of grains under various climatic situations. This study's data are obtained from primary and secondary sources. The collection of secondary sources of information aided in analyzing the three scenarios' coverage (1971 – 1980; 1981 – 1990; and 1991 – 2000). Out of the 900 respondents in the core data set, only 850 cases are found to be meaningful. The findings suggest that if grain production does not keep up with population expansion in an unfavorable climate, the number of deaths caused by hunger may rise. Nonetheless, farming production is significantly impacted by responses to climate change. According to Audu et al. (2013), the study's objectives included identifying the many climate change variables that tend to affect agriculture and proposing mitigation techniques. The study aims at evaluating the implications of climate change on agricultural activities in Nigeria. A portion of the information included in their work come from recent research conducted by different authors and included information on the beginning and end of the rainy seasons in Kaduna, Kano, and Sokoto and the causes of changes in agricultural yield in Nigeria's semi-arid region. The Nigeria Meteorological Agency, Oshodi, Lagos, provide the temperature and daily rainfall data that the author used to calculate the mean decadal temperature for six (6) meteorological stations (Lokoja, Yola, Sokoto, Ibadan, Owerri, and Kano), as well as the frequency and duration of dry spells at Lokoja and its environs for 30 years (1981 - 2010). The topic of climate change and its effects on the ecosystem are examined by Olaniyi, Funmilayo, and Olutimehin (2014). They show and discuss the consequences of both natural and human-caused phenomena on climate change, global warming, and the environment. The study goes on to emphasize how important it is for governments at all levels to provide sufficient funding for the creation of geoinformation and to foster a culture that embraces its use to respond appropriately and proactively to environmental sustainability, national development and global warming.

One of the world's poorest nations, Sierra Leone, is threatened by climate change in various ways, endangering important economic sectors and raising the possibility of more extensive environmental damage, according to USAID from the American People (2016). A recent Ebola outbreak and a decline in mining activity undid the socioeconomic gains gained since the civil war ended in 2002, placing the nation in a vulnerable position to deal with the effects of climate change. Yila et al. (2023) evaluate how variations in temperature and rainfall affect the productivity of crops in Sierra Leone's Moyamba district. For the perception study, 30 Agricultural Extension Workers (AWEs) in the Moyamba district are specifically chosen as respondents, and 400 farmers are chosen at random from Farmer-Based Organizations (FBOs) in 4 chiefdoms. Kendall's test of concordance and descriptive statistics are employed to examine the information gathered from the farmers and AEWs. Monthly, seasonal, and annual time series of data are gathered from Njala University and the Sierra Leone Meteorological Agency for the examination of temperature and rainfall variability and trends from 1991 to 2020. Farmers believe that three main unfavorable weather events high temperatures, erratic rainfall, and droughts have a significant impact on the yield losses of the main crops grown in the district.

From the literature reviewed, it is deduced that there is limited literature on climate change and actual output in Africa. Thus, this paper fills this gap in the literature by exploring how climate change, using GHG emission s as a proxy, impacts the actual output of Nigeria, Ghana, Liberia, The Gambia, Cabo Verde and Sierra Leone. The findings of this study show the degree at which greenhouse gas emissions affect the output levels inAFRITAC West-2 Member Countries which can be used to design climate-related capacity development programmes in this region. The remaining sections of the document are arranged as follows: Materials and Methods are presented in Section 3; the results are covered in Section 4; and the study is concluded in Section 5.

3. Materials and Methods

The data used in this analysis are panel data which ranged from 1980 to 2022 covering variables such as agricultural greenhouse gas emissions, building and other sectors' greenhouse gas emissions, energy Industries' greenhouse gas emissions, mineral industry greenhouse gas emissions, road transport greenhouse gas emission and output for African countries. These data were obtained from the IMF database. From the data, we create a functional relationship among the variables. Thus, the functional relationship is specified as:

$$output = f\left(agric_{ghg}, build_{ghg}, Energyindus_{ghg}, Minind_{ghg}, road_{ghg}\right) \quad (1)$$

Equation (1) could be respecified as a mathematical equation as:

$$output = a_0 + a_1 agric_{ghg} + a_2 build_{ghg} + a_3 Energyindus_{ghg} + a_4 Minind_{ghg} + a_5 road_{ghg} \quad (2)$$

To estimate the System GMM, equation 2 is transformed into a dynamic panel model. By including a lagged dependent variable as an independent variable or predictor in the model, the model is transformed into a dynamic panel model. The dynamic panel model is specified as:

$$output_{i,t} = \propto + a_1 output_{i,t-1} + a_2 agric_{ghg_{i,t-1}} + a_3 build_{ghg_{i,t-1}} + a_4 Energyindus_{ghg_{i,t-1}} + a_5 Minind_{ghg_{i,t-1}} + a_6 road_{ghg_{i,t-1}} + d_i + \varepsilon_{i,t} \quad (3)$$

Where output is the dependent variable, agric_ghg, build_ghg, Energyindus_ghg, Minind_ghg, and road_ghg, are the explanatory variables. Specifically, agric_ghg is agricultural GHG emission, build_ghg is building and other sector's GHG emission, Energyindus_ghg is energy industries' GHG emission, Minind_ghg is mineral industry GHG emission, and road_ghg is road transport GHG emission. $\propto$ is the intercept, $a1$, $a2$, $a3$, $a4$, $a5$, $a6$ are the parameters of the model, d_i is the fixed effect time, $\varepsilon_{i,t}$ is a component of the model, i is the number of observations (cross-section), and t is time (time series).

The choice of the System Generalized Method of Moments (System GMM) model for this analysis is guided by the dynamic and complex nature of the relationship being studied, as well as the characteristics of the dataset. The relationship between greenhouse gas emissions from various sectors and economic output is inherently dynamic, with past values of economic output likely influencing current levels. To capture this temporal dependence, the model includes the lagged dependent variable as a predictor, allowing us to reflect how historical output levels shape current outcomes. One of the main challenges in such analyses is endogeneity, where explanatory variables like sectoral greenhouse gas emissions may be influenced by unobserved factors or even by the dependent variable itself. For instance, economic growth could drive higher emissions in certain sectors, creating a feedback loop. The System GMM approach is particularly suited to address this issue, as it uses internal instruments derived from the dataset—specifically, lagged values of the dependent and independent variables—to account for this potential reverse causality and omitted variable bias.

Given the nature of the dataset, which comprises panel data spanning multiple African countries from 1980 to 2022, the System GMM is an ideal methodological choice. It is designed to handle large cross-sectional units (countries) with a moderate time dimension, accounting for country-specific differences that do not vary over time, such as geography or structural economic factors. By incorporating fixed effects, the model controls for these time-invariant characteristics, ensuring that the estimates focus on variations within each country over time.

Furthermore, the System GMM model is effective in addressing common issues in panel data analysis, such as serial correlation and heteroscedasticity in the error term. It combines equations in both differences and levels, enhancing the efficiency and robustness of the estimates. This dual approach ensures that the model not only eliminates biases caused by fixed effects but also incorporates additional instruments to improve accuracy. In economic terms, the relationship between emissions and output is not only immediate but also unfolds over time. The dynamic nature of the System GMM allows for capturing both short-term and long-term impacts, offering a comprehensive view of how sectoral emissions influence economic performance. Additionally, the model is well-suited for situations where the number of cross-sectional units exceeds the time periods, as it avoids biases that simpler fixed-effects models might introduce.

4. Results

The descriptive statistics, unit root test, and system generalized method of moments are the three estimated test outcomes that are explained in this section.

The descriptive statistics displayed in Table 1, show that agric_ghg has a value of 8.97 which is the highest mean value in the variable, followed by build_ghg with a value of 5.35. The value with the least mean value is min_ind_ghg with a value of 0.65. The standard deviation shows that agric_ghg has the highest value with a figure of 18.44, road_ghg is the next figure with a value of 11.25, and the variable with the least standard deviation is output with a value of 1.05e+11. All the variables had a value of 0 as their minimum value. The variable with the highest maximum value is agric_ghg with a value of 79.19, followed by road_ghg with a value of 59.44. From the panel it shows that the variable consists of 258 observations. It shoud be noted that the unit of these greenhouse gas are in C02.

Table 1. Summary statistics.

	Output	agric_ghg	build_ghg	Energyindus_ghg	Min_ind_ghg	road_ghg
Mean	3.95e+10	8.97	5.35	2.85	0.65	5.02
Std. dev	1.05e+11	18.44	11.20	6.29	1.64	11.25
Min	0	0	0	0	0	0
Max	5.74e+11	79.19	42.66	29.50	9.31	59.44
Obs	258	258	258	258	258	258

Source: authors computation using Stata.

In Table 2, we put all the variables into a unit root test, to test for their stationarity. Since it is unbalanced data, the fisher type unit root test is estimated. We find that the variables are stationary at levels, I (0) and first difference, I (1), All the variables in the model were stationary at first difference except min_ind_ghg which is stationary at levels.

Table 2. Unit root test result.

		Level z					First difference	
Variable	p		l	pm	p	z		pm
Output	0.45	4.90	5.29	-2.36	155***	-10.99***	-17.71***	29.19***
agric_ghg	10.74	-0.41	-0.36	-0.26	40.24***	-2.54***	-3.64***	5.77***
build_ghg	13.92	-0.90	-0.87	0.39	30.81***	-2.03**	-2.62***	3.84***
Energyindus_ghg	13.52	-0.89	-0.85	0.30	65.85***	-6.11***	-7.49***	10.99***
Min_ind_ghg	19.88*	-1.69**	-1.74**	1.61*	-	-	-	-

Source: authors computation using Stata.

Table 3, shows the System generalized method of moment, which is an econometric technique used to estimate model parameters by minimizing the difference between the sample moments and the corresponding model moments. It is commonly used in econometrics to address endogeneity and other issues. In studying the impact of climate change on economic output, there may be endogeneity issues, where explanatory variables, such as greenhouse gas emissions, could be correlated with the error term. This correlation could arise from omitted variables, measurement errors, or reverse causality (e.g., economic output influencing emissions levels).

For over a century, the method of moments approach has been used to estimate parameters (Stigler, 1986). According to Wansbeek(2017), for the past 30 years, empirical economics research has increasingly relied on the Generalized Method of moments (GMM), a conceptually straightforward and adaptable estimate technique. The availability of so-called moment equations or moment conditions is necessary for the application of GMM. An estimate of the difference and system-GMM is made. That being said, we get our ultimate conclusion from the system-GMM outcomes. To address the shortcomings of General Least Square (GLS) estimators, we choose to use system-GMM. The GLS estimator is biased and inconsistent because it uses the quasi- demeaning of the data, which results in a correlation between the dependent variable and the quasi- demeaned residuals.

The result in Table 3, shows that the System Generalized Method of Moments 1, is preferable to other general methods of moments estimated because most of the variables are significant in system general methods compared to other GMM estimators. The table shows that all the variables are significant at a 1 % level of significance, the table also shows that greenhouse gas emission from agriculture harms the actual growth of AFRITAC West 2 countries. The System GMM results indicate that past output contributes to a 0.09% increase in current output. Agricultural GHG emissions negatively impact output, reducing it by $8.5 billion. In contrast, emissions from buildings, energy industries, mining, and road transport contribute positively, increasing output by $1.00 billion, $2.70 billion, $1.16 billion, and $2.56 billion, respectively. This suggests that while emissions from agriculture hinder growth, those from other sectors drive economic expansion, highlighting the need for sustainable policies. The post-estimation test shows that the System Generalized Methods of Moments was appropriate and fit to be modeled, this is because the autocorrelation and Hansen statistics satisfied the model. The rule of thumb which is AR (2)> 0.05 for the autocorrelation, showed that AR (2) is about 0.34. The Hansen statistics probability is 1, which is over 0.9, therefore it has to be ignored.

Table 3. System Generalized Method of Moments.

VARIABLES	(1) DGMM1	(2) DGMM1-CL-a	(3) DGMM2	(4) DGMM2-CL-a	(5) SGMM1	(6) SGMM2
L.doutput	0.0765***	-0.0118	0.561	0.0914**	0.0867***	0.590
	(0.00736)	(0.0163)	(0)	(0.0456)	(0.00843)	(0)
dagric_ghg	-8.387e+09***	-8.004e+09***	-1.718e+09	-5.529e+09***	-8.497e+09***	-1.557e+09
	(4.030e+08)	(4.469e+08)	(0)	(1.530e+09)	(4.074e+08)	(0)
dbuild_ghg	9.808e+09***	9.201e+09***	0	4.887e+09**	1.004e+10***	0
	(9.546e+08)	(1.013e+09)	(0)	(2.148e+09)	(9.460e+08)	(0)
dEnergyindus_ghg	2.610e+09**	2.285e+09**	3.899e+09	3.436e+09***	2.701e+09***	3.880e+09
	(1.028e+09)	(1.137e+09)	(0)	(8.955e+08)	(9.722e+08)	(0)
Min_ind_ghg	3.279e+08***	-2.933e+09***	0	0	1.162e+09***	0
	(5.243e+07)	(1.050e+09)	(0)	(0)	(5.739e+07)	(0)
droad_ghg	2.684e+09***	3.384e+09***	5.553e+08	2.158e+09***	2.560e+09***	4.490e+08
	(2.134e+08)	(2.987e+08)	(0)	(3.736e+08)	(2.111e+08)	(0)
Constant					5.111e+08	0
					(4.641e+08)	(0)
Observations	240	240	240	240	246	246
Number of crossed	6	6	6	6	6	6
Hansen_test	1.619	0.920	1.619	0.920	1.631	1.631
Hansen Prob	1	0.922	1	0.922	1	1
Sargan_test	362.6	55.29	362.6	55.29	368.2	368.2
Sargan Prob	2.29e-10	0	2.29e-10	0	1.32e-06	1.32e-06
AR(1)_test	-1.094	-1.145	-0.988	-1.128	-1.097	-0.990
AR(1)_P-value	0.274	0.252	0.323	0.259	0.273	0.322
AR(2)_test	-0.964	-1.021	0.810	-0.914	-0.955	0.856
AR(2)_P-value	0.335	0.307	0.418	0.361	0.339	0.392
No. of Instruments	215	10	215	10	256	256

*Note: *** p<0.01, ** p<0.05, * p<0.1; DGMM1 & DGMM2 denote One-Step & Two-Step GMM respectively.*

5. Conclusions and Policy Implications

According to CDP Africa report (2023), at 3.8%, Africa emits the least amount of greenhouse gases globally, compared to 23% in China, 19% in the United States, and 13% in the European Union. This might be the reason why the result of the system GMM shows that most of the greenhouse gas emissions have a positive impact on the economic growth of African countries. This is because most of the emissions of this greenhouse gas into the climate do not come from Africa, instead, they come from the developed countries, but our result indicates that greenhouse gas emission from agriculture reduces economic growth the highest in African countries compared to other greenhouse gas emissions. This might be because of the high rate of agricultural activities in African countries, which eventually leads to a high level of greenhouse gas emissions in these countries. This result conforms to the literature of Collier, Conway, and Venables (2008).

Based on the findings, the policies that can be used to mitigate the negative impact of dagric_ghg on doutput in African countries are; sustainable farming practices which can help in promoting sustainable agricultural practices that reduce greenhouse gas emissions, such as agroforestry, organic farming, and precision agriculture. These can help mitigate the environmental impact without significantly hindering economic activity. Adoption of climate-smart technologies such as efficient irrigation systems, renewable energy use, and improved livestock management practices, can reduce greenhouse gas emissions in the agricultural sector of African countries. These technologies can enhance productivity, reduce resource use, and contribute to sustainable development. Capacity building and knowledge sharing can educate farmers on sustainable land management, efficient water use, and low-emission farming techniques. This can help minimize emissions while maintaining or even improving economic activity. Financial incentives and support to farmers can provide economic motivation for farmers to implement environmentally friendly practices, thereby encouraging sustainable practices. Investing in Research and Innovation for low-emission agricultural practices specific to African countries, can yield technological advancement and knowledge that benefit both the environment and the economy. This can drive sustainable agricultural development and create new economic opportunities.

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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