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Research Article

Transposed Second-Generation Environmental Kuznets Curve, Changing Climate Patterns, and Selected Development Indicators

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ABSTRACT

This paper examined the impact of changing climate patterns (represented by square and cubic CO_2 emissions) on selected development drivers (proxy by gross domestic product [GDP] per capita [GDPC] and official development assistance [ODA]). Environmental Kuznets curve (EKC) provided the theoretical backdrop of this study, referred to as the core second-generation EKC (SGEKC) hypothesis. SGEKC was modified to obtain the transposed SGEKC. The transposed SGEKC was conceptualized based on the one-way criticism of the EKC. An unbalanced PMG (ARDL) method was utilized to investigate the impact of the changing climate patterns on GDPPC–(to capture EKC hypothesis) and ODA–(to capture pollution haven hypothesis) in the West African Monetary Zone (WAMZ). This study, therefore, leveraged data from world development indicators between 1970 and 2019. The result showed that the one-way impact of CO_2 emissions on GDPC has a long-run N-shaped. The outcome of the GDPC model (in the transposed SGEKC hypothesis) is consistent with the core SGEKC hypothesis. On the other hand, the impact of CO_2 emissions on the ODA showed an inverted N-shaped in the long run. The inverted N-shaped relationship does not support pollution-haven hypothesis in the long-run. The results, therefore, imply that the changing climate patterns have a more disruptive impact on income per capita and less on ODA. In the short-run, the result showed the existence of an inverted-N and N-shapes for GDPC (SGEKC does not hold) and ODA (presence of pollution haven) respectively. In conclusion, changing climate patterns present a long-run threat to the economy of WAMZ which in turn could disrupt economic agents' interactions, de-optimize economic aggregates and economic equilibrium, as well as negatively affect the attainment of a long-run regional development objectives. This study recommends that WAMZ's government(s) should fast-track the implementation of robust carbon pricing mechanism and abatement policy that would enable climate mitigation policy, improve the regions nationally determined contributions (NDCs) targets, and insulate the economies from policy uncertainty associated with climate change.

Keywords: climate change, development, environmental Kuznets curve, climate patterns, West African Monetary Zone (WAMZ), transposed SGEKC, UN Secretary-General Antonio Guterres, pollution haven hypothesis

INTRODUCTION

Scholars are concerned about the emerging feedback underpinning environment (climate change) and the growth nexus as well as the overwhelming drawbacks associated with lax environmental regulations (multinational enterprises' cross-border investment) which often resurrects global competitiveness uncertainties. Presently, the underlying issues prevalent on climate change-growth debate revolve around how to implement policies that

a. robustly deepens the global mitigation and adaptation frontiers;
b. improves carbon pricing i.e., carbon tax and cap-and-trade, abatement spending, and carbon trading;
c. limits carbon leakages and dirty good transfer through standard, inclusive, and resilient environmental regulations regime; and
d. as well as set in motion optimal instruments that are; green, resilient, inclusive, and sustainable (GRIS) in order to achieve net zero emissions target by 2050.

The motivation of this paper is, therefore, anchored on the warming issued by UN Secretary-General, Antonio Guterres. Guterres (2020) opined that imminent famine (poverty) due to climate shocks is inevitable. Guterres (2020) further warned that "more than 100 million people could navigate into extreme poverty due to climate change" (Khoday and Ali, 2018). In the literature, there are robust contention that developing countries are too poor to be green (Martinez-Alier, 1995). Despite global response to improve environmental quality, evidence of rising incidence of environmental degradation, oil spillages, and greenhouse gas (GHG) largely contributed by the anthropogenic activities yet persist. Therefore, it will be a lifetime tragedy to overlook the implosive and damaging statistical properties of climate patterns (i.e., the quadratic and cubic dimensions) on selected development drivers.

As a point of departure, the contribution of this paper is to expand the growth and environment debate by transposing and re-estimating the core second-generation EKC model (SGEKC). Transposed SGEKC is obtained by rearranging the functional relationship in the core SGEKC hypothesis (Grossman and Krueger, 1991). Thus, the concern of this paper is to investigate the impact of the first stage carbon dioxide (CO_2) emissions, second stage CO_2 emissions, and third stage CO_2 emissions (a proxy for the three-dimensional changing climate patterns) on gross domestic product per capita (GDPC) and official development assistance (ODA). This paper is anchored and built on the critique that the core SGEKC hypothesis does not account for feedback causality. The core SGEKC hypothesis (also EKC) assumed away the physical and transition risks (impact, shock) emanating from changing climate patterns (CO_2) on growth trajectory (development indicator). Hence, the imperative to re-estimate the core SGEKC hypothesis in order to accommodate the one-sided causality critique levelled against the core SGEKC theory (Arrow et al., 1996).

Deepening climate patterns and development issue is complex, multifaceted, and operates within a coupled system (IPCC, 2022). The coupled system holds that climate, biodiversity, ecosystem, and human inputs are interdependent and mutually non-exclusive, as such any perceptible shocks measured in terms of damages and consequences of the velocity of changing climate patterns, could make the coupled system worse-off. Therefore, the resultant effects of these damages originate in the form of risks, hazards, and vulnerability (RHV) effects. Thus, the inevitable occurrence of the RHV provokes discourse on the policy problems of rebalancing economy and environment goals in order to attain the sustainable development goals (SDG) targets. The problems of rebalancing growth-CO_2 emissions model create what is termed a super-wicked problem. Such that changing climate patterns, generate an unacceptable physical risk that disrupts development desiderata as well as efforts to reverse emissions trend enthrones strict conditions e.g. transition risk, on the growth model and vice-versa. RHV effects are irreversible scenarios which thus suggest that climate change control and management policies

a. impose restrictions that structurally modify and alter the productivity conditions and
b. places overbearing distortion on income making it increasingly difficult for development strategies in developing countries to attain conditions for development (Hertel and Rosch, 2010).

For example, the unpredictable changing climate patterns inevitably generate shocks, uncertainties, hazards, and risks that cause structural damages to the market fundamental, real variables e.g., output and employment, and economic assumptions that govern the economic space (IPCC, 2022).

While, the impact of changing climate patterns on development drivers persist unimpeded, there is a vex issues of controversy in the literature about the form of relationship between climate and growth. Hence, in order to align with the extant literature, the paper's concern is to squarely account for the effects of CO_2 on development drivers in the WAMZ. The motivating question becomes what is the impact of the doubling and cubic function of a changing climate pattern on ODA and GDPC in the WAMZ? WAMZ includes the Gambia, Ghana, Guinea, Nigeria, Liberia, and Sierra Leone. WAMZ is a monetary bloc within the Economic Community of West African States (ECOWAS), with clear macro-economic convergence criteria to achieve economic and monetary union (EMU).

This paper is subdivided into parts namely; introduction, literature review, data and methodology, results and discussion, and conclusion and policy recommendation.

LITERATURE REVIEW

Theoretical Literature

The literature acknowledges two generations of the Kuznets curve. They are first generation Kuznets curve (FGKC) and core second-generation environment Kuznets curve (SGEKC). First-generation Kuznets curve (FGKC) theorized that a two-phased dimension: increasing and decreasing functional relationship between income inequality and economic development exist over time (Kuznets, 1955). FGKC stated that income inequality first rises and then falls as economies develop. Conversely, in the second generation, the concept of core second-generation EKC (SGEKC) further hypothesized a two-dimensional relationship between pollution events (environmental degradation) and economic growth per capita through scale, composition, and technique channels (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992). Analytically, the core second-generation environmental Kuznets curve (SGEKC) is employed to estimate the relationship between CO_2 emissions and income per capita (proxy for economic growth). The core SGEKC defines a functional relationship between CO_2 (regressand) and growth (regressor).

Grossman and Krueger (1991) opine that there is an existence of a quadratic and non-linear relationship between income per capita (regressors) and CO_2 (regressand). Therefore, the core SGEKC succinctly captures the responsiveness change of environmental conditions to a two-stage per capita income effect. By implication, two-stage per capita income effect is utilized to measure an intertemporal economic shift in the production frontier of a country. So, core

SGEKC theory, therefore, explains that in the initial stage of economic growth, there is an upward trend in pollution emissions, thus environmental quality declines. But at a later and advanced stage of economic growth beyond some level of per capita income, the pollution emissions trend reverses downward. This implies that at a high- economic growth per capita, given the level of a new technique, innovation in production, mitigation process, etc. environmental quality improves (fewer pollution emissions). It also implies that environmental impacts or emissions per capita income decline as production expands due to the rationality employed by economic agents towards the application of cost-effective technology and environmental-sensitive technology (Stern, 2008). Based on development realities, proponents of core SGEKC argued that greater economic activity constitutes a task to environmental quality through tripods channels. They are; the scale, composition, and technique effects. These lead effect influences the relationship between environmental pollution and income per capita. Overtime, SGEKC have been estimated through; the unitary core-SGEKC, the squared core-SGEKC perspective and the cubic core-SGEKC perspective. The variant core SGEKC are represented by an apriori expectations given as; for the initial stage $\beta_1\rho^1 > 0$ (increasing), and the later stage is represented as; square GDPC $\beta_2\rho^2 < 0$ (decreasing) and cubic GDPC $\beta_3\rho^3 > 0$ (increasing), *where* $\beta_i\rho^k$ is the parameters, β is coefficient, ρ is GDP per capita, *i*=1, 2, 3, and k measures the degrees of intensity in the shift of GDP per capita respectively. These <or> signs connote a decreasing (economies of scale) and an increasing (diseconomies of scale) pattern in the relationship between environmental pollution and GDP per capita.

Theoretically, the behavior of the later stage relationship between climate change (environmental pollution) as a function of square GDP per capita ($\beta_2\rho^2 < 0$) is found to be an inverted U-shaped i.e., the quadratic school of thought. Similarly, the cubic school of thought ($\beta_3\rho^3 > 0$) viewed the functional-linear relationship between environmental pollution and cubic GDP per capita as an N-shaped (Grossman and Krueger, 1991). Panayotou (1993) finding is consistent with core SGEKC. Panayotou (1993) argued that higher levels of development, coupled with investment and enforcement of environmental regulations result in levelling off and the gradual decline of environmental degradation. Inverted U-shaped implies that in the infant stage of economic growth, degradation and pollution increase, and after a certain period which is represented by high-income levels, economic growth lead to environmental improvement (Stern, 2004). Within the core SGEKC structure, Kasperowicz (2015) found that the relationship between GDP and CO_2 emissions is negative in 18 EU member countries. Similarly, Tong et al. (2020) found a mixed relationship between economic growth and CO_2 in E7 countries comprising Brazil, India, Indonesia, Mexico, China, Russia, and Turkey. Mohamed et al. (2012) captured the Middle East and North African countries experience; more so, asserted that GDP exhibited a quadratic relationship with CO_2 emissions across the region.

The foremost critiques of the SGEKC have argued that the econometric framework of SGEKC is subjective (Arrow and Piemental, 1995; Copeland and Taylor, 2004; Stern, 2008). Dasgupta et al. (2002) argued that SGEKC is monotonic. There are two perspectives to this argument namely new toxics and race to the bottom scenarios. The new toxics scenario posits that core SGEKC does not hold for new toxics e.g., carcinogenic chemicals, and CO_2. On the other hand, the race to the bottom scenario asserts that core SGEKC is inconsistent with data, because of the outsourcing operation by developed countries in which they outsource dirty production to developing countries thereby making it increasingly difficult for emissions to be reduced. The core SGEKC further argued that arising from inevitable technological changes, SGEKC shows a downward curve behavior shifting to the left (Stern, 2004). Stern (2004) contends that the proximate causes of the core SGEKC relationship are namely; the scale effect (expansion), the changes in economic structure or product mix, changes in the technological state, different industrial pollution, and changes in input mix.

In a similar vein, the decomposition of pollution a major issue in the core SGEKC has received attention. Specifically, Selden and Song (1994) estimated core SGEKCs using quadruplet-dimensional series namely Sulfur dioxide, Nitric oxide, suspended particles (SPM), and CO_2. Shafik and Bandyopadhyay (1992) studied core SGEKC from ten indicators. Grossman and Krueger (1991) estimated core SGEKCs utilizing sulphur oxide, dark matter, and SPM. In a related development, pollution was decomposed into local pollution and global pollution in the study of EKC (Lopez, 1994). According to Lopez (1994), local pollution is agreeable to core SGEKC rather than global pollution. Also, pollution generated from consumption rather than production was considered in the study such as McConnel (1997). Arrow et al. (1996) asserted that core SGEKC failed to estimate and integrate the existence of feedback emanating from the impact of environmental damages or shocks on the economy. From, the super-wicked problems there is the presence of feedback that exist in the economic growth and environmental degradation. The policy planning problem depicts a trade-off implying the complexities associated with the environmental-economic growth nexus. Moreover, the climate irreversibility issue is not severe enough to reduce the level of income in the long run.

It is sufficiently adequate to refute the assumptions of one-dimensional nexus between increasing income per capita and the dual nature of pollution; increasing and decreasing phase of pollution. According to Stern (2004), in the developed countries core SGEKC seems to be accommodative of present quality environmental trends. The EU-US have been able to catalyze the de-carbonization (green economy) of their economies at same time achieve higher economic growth level. Therefore, the assumption in core SGEKC assumption that all pollutants exhibit an analogous trend is highly spurious. Based on the evidence from econometric estimation the issue of multi-collinearity and autocorrelations might surface in the model because of the presence of the quadratic dimension of income per capita which makes the equation faulty. The interpretation of the core SGEKC is that whilst it is simple to employ as a background theoretical framework, it is unable to capture the issues of cross-border leakages and regional emissions transfer. For example, the cross-border leakages between less environmental regulated environmental location and strict environmental location causes instability and loss of competitiveness in the attainment of environmental goal. Similarly, the core SGEKC has only been verified for a limited environmental indicator, the model did not take into cognizance cross-country spillover between countries. That is, core SGEKC is unable to capture the issue of carbon tax between non-pollutants country and pollutants countries. The absence of the institutional regulatory framework and agency to legislate, control, and robustly deepen the attainment of optimal environmental quality clearly connotes that the core SGEKC is primarily a model that provides an apriori linkage existing between income per capita and pollution. Hence, core SGEKC theory fails to accommodate typography and regional climatic difference in magnitude and dimension which therefore raises complications pertaining to pollution haven, race to the bottom and gains from trade. He (2007) found that it is inappropriate that all measures of environmental damages can be recovered; environmental systems are incapable of returning to their initial conditions once certain environmental thresholds have been reached.

Literature typifies four pathways that measure the shock channels through which unpredictable climate patterns impede development. These pathways are namely; direct physical pathway e.g., high temperatures, extreme rainfall, heat waves, and natural disasters (Aragie, 2013), indirect transitory pathway e.g., transitory-demand and supply shocks, intermediate pathway e.g., financial shock, health shock, and agricultural price shock, and the feedback pathway that loops the impact of development on environment quality (Hallegatte et al., 2016). Consequently, due to the global warming effects: unpredictable weather patterns and climate change, the underlying philosophy governing the core SGEKC functionality becomes untenable. Thus, it is increasingly difficult to assume away the disruptive and feedback effects of changing climate patterns on developing economies as theorized in the core SGEKC. It is based on the feedbacks that this paper conceptualized the transposed SGEKC. Unlike in the core SGEKC function, transposed SGEKC framework defines growth (regressand) as a function of pollution (regressor). Similarly, the transposed SGEKC builds on the logic that pollution create physical and transition risks that cause shocks within the economic space. The apparent difference between FGKC, core SGEKC, and the transposed SGEKC is the attention placed on inequality, growth, and pollution respectively.

Based on the foregoing conception, this study carried out further modifications to core SGEKC called transposed SGEKC. The major concern in this modification is to estimate the impact of the quadratic and polynomial (cubic) climate change events on the development lens. Emerging awareness of the disconcerting weather and flooding events has ignited a scholarly interest to rethink the impact and influence of quadratic or cubic climate change effects (a proxy for environmental pollution) on GDPC and ODA in developing countries.

Empirical Literature

Ibeabuchi et al. (2022) in an ARDL, causality, and IRF system found that FDI, fossil fuel consumption are enablers of GHG emissions, GDP growth and merchandise trade de-enablers GHG emissions, while electricity use and fertilizer consumption showed mixed findings across the regions. The study found that a 1% shock in GHG cause monetary volatility. Using a comprehensive hydrologic and hydraulic model, the results showed that the different patterns of rainfall cause variability in flood depths (Hettiarachchi et al., 2018). The forecast of rainfall-driven flood risk principally accounted for by climate change was captured in Kundzewicz et al. (2013). The result of the study is consistent with the IPCC SREX assessment. The study showed distinguished two major flooding such as flash flooding and urban flooding are caused by climate change but the nature of rainfall is connected to the detailed nature, magnitude, or frequency of climate change. Vermeulen et al. (2012) found a bi-causality between food systems and climate change. The core drivers in this bi-causality are the prevailing social conditions. Schreider et al. (2000) in a study titled "climate change impacts on urban flooding" explained that GCMs' slab model showed that between 2030 and 2070 climate change might cause less significant urban flood damage. On the contrary, the stochastic weather generator technique found that the higher the CO_2 concentration the higher the damage. Also, the study utilized a hydrological model to estimate the CO_2 and flood relationship. The study found that doubling CO_2 conditions cause a positive impact on flooding though the result varies from place to place. Milly et al. (2002) identified radioactive anthropogenic climate change and flood risk causality through the intensification of the global water cycle. The study concludes that the flood trend is continuously based on the climate change impact using both stream flow measurement and numerical simulations of the anthropogenic climate changes. Flood affects daily calorie consumption by approximately 60 kcal. Flood brings about an increase in the deficiency level of iron, vitamin A, and vitamins C by 11, 12, and 27%, respectively. The risk of exposure to natural disasters leads to a decline in income by 3%, drives 3% of the household to poverty, and causes significantly lower diet quality and quantity with difficult consumption coping strategies (Oskorouchi and Sousa-Poza, 2021). Dorward and Kydd (2004) posit that erratic rainfall lowers the productivity of rural economies through a decline in returns on investment, distortions of investment by increasing investment hazard, and discouraging investment due to the risk-averse nature of investors.

Grossman and Kreuger (1991) and Shafik and Bandyopadhyay (1992) conceptualized three relationships in core SGEKC i.e. scale effect, composition effect, and technique effect, Larson et al. (2012) revealed that there is the presence of a non-monotonic, inverted-U shaped relationship between several of pollutants such as CO_2, SO_2, and income. The outcome of the study implies a dynamic relationship between the environment and growth with the movement toward economic development. Amaefule et al. (2022) adopted the Granger causality and co-integration test to examine the nexus between fossil fuel consumption, CO_2 emissions, and economic growth in high-income and low-income countries. The study found that there exists an

a. unidirectional causality emanating from RGDP to CO_2 emissions in high-income countries,
b. absence of causality between RDGP and CO_2 emissions in low-income countries, and

c. absence of causality between fossil fuel consumption and RGDP, and RGDP and CO_2 emissions in high-income and low-income countries.

Amaefule and Ebelebe (2022) in a study titled climate change scare and FDI migration with data obtained from 1970 to 2019 found that the change in FDI migration into Sierra Leone brought about upward CO_2 emissions. Also, dynamic movement of FDI into Nigeria showed a mixed result. The study employed NARDL method.

Thongrawd and Kerdpitak (2020) utilized VECM to examine the causal relationship between energy consumption, CO_2 emissions, and economic growth in four ASEAN countries between 1980 and 2018. The CO_2 emissions and GDP per capita growth form a nonlinear core SGEKC relationship in the long run. The granger causality test statistics capture a unidirectional causal association connecting energy consumption and CO_2 emissions to economic growth. While in the short-run, unidirectional Granger causality is found from CO_2 emissions to energy consumption.

Tong et al. (2020) in a study titled economic growth, energy consumption, and CO_2 emissions in the E7 countries adopted a bootstrap ARDL bound test. The study found that there is no co-integration between economic growth, energy consumption, and CO_2 emissions in China, Indonesia, Mexico, and Turkey. In another related development, evidence of co-integration is found for Brazil when CO_2 emissions are the dependent variable, and for India and Russia when energy consumption is the dependent variable. The result also found that there is a short-run Granger causality between energy consumption and CO_2 emissions for E7 countries except for Indonesia, and short-run Granger causality from economic growth to CO_2 emissions for Brazil, India, Mexico, and China. Also, the study observed a short-run Granger causality emanating from economic growth to energy consumption for Brazil, India, Indonesia, Mexico, and China, as well as from CO_2 emissions to energy consumption for all E7 countries. Furthermore, the results consistently show that energy consumption is the main cause of CO_2 emissions.

Olatayo et al. (2019) examined the annual time series data between 1970 and 2015 with a VECM instrument. The study found a mixed interrelationship between economic growth and environmental degradation. Specifically, in the long-run economic growth is associated with a rise in environmental degradation, and environmental degradation leads to a decline in economic growth. The study affirms that environmental degradation reduces economic growth while economic activities increase environmental degradation, and vice-versa.

Oriavwote and Oyovwi (2019) in a study to verify the economic implications of environmental degradation, as well as, to ascertain the empirical relevance of core SGEKC utilizing time series data from1986-2017. They adopted ordinary least squares (OLS) and Granger causality methods. The result showed that per capita income has a positive and insignificant relationship with carbon emission. The square of the per capita income has a positive and insignificant relationship with carbon emission. This implies the absence of core SGEKC in Nigeria. Secondly, from the Granger causality test, the study found the absence of a causal relationship between carbon emission and per capita income.

Gill et al. (2018) confirmed that many of the development schemes employed by high-income countries possess costs i.e., environmental degradation, greater pollution, loss of biodiversity, risks to human health, over-exploitation of natural resources, and unsustainable environmental channels. Kasperowicz (2015) in a study titled economic growth and CO_2 emissions adopted a panel data approach to investigate the relationship between CO_2 emissions and economic growth for 18 EU member countries between 1995 and 2012. The study found that the long-run relationship between GDP and CO_2 emissions is negative. Bur, the short-run relationship between GDP and CO_2 emissions is positive. Thus, CO_2 emissions and growth are influenced by time.

Arouri et al. (2012) in a study titled energy consumption, economic growth, and CO_2 emissions in the Middle East and North African countries was anchored on Ang (2007), Apergis and Payne (2009), and Payne (2010) implemented bootstrap panel unit root tests and co-integration techniques over the period 1981-2005. The results show that in the long-run energy consumption has a positive significant impact on CO_2 emissions. Also, the study found that real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole. However, although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases, hence providing poor evidence in support of the EKC hypothesis. Thus, the findings imply that not all MENA countries need to sacrifice economic growth to decrease their emission levels as they may achieve CO_2 emissions reduction via energy conservation without negative long-run effects on economic growth.

Ismail and Mawar (2012) computed Malaysian experience employing Johansen's (1995) approach in order to determine energy, emissions, and economic growth nexus, as well as adjusting the model with the presence of trade activities from 1971 to 2007. From the study, there is the presence of long-run causality connecting energy, emission, and economic growth, and among energy, emissions, export, and capital. But, in the short-run Granger non-causality test shows that there are unidirectional causalities emanating from

a. energy to economic growth and capital,

b. economic growth to capital, and

c. emissions to export.

The data from Malaysia showed that in the short-run results showed no presence of feedback between energy use and economic growth. In contrast, in the long-run, the feedback hypothesis is observed. The study suggests that the policymakers in Malaysia focus on long-run conservation policies.

Taguchi (2012) opined that SO_2 emissions follow the expected inverted-U shape while CO_2 tends to increase in line with an increase in per capita income. Akpan and Chuku (2011) adopted the ARDL method to x-ray the relationship between economic growth and environmental degradation in Nigeria from 1960 to 2008. The study empirically showed that there is an absence of the SGEKC hypothesis. Basically, the study found an N-shaped relationship with a turning point of $77.27. The paper asserts that hypothesized SGEKC does not provide an appropriate policy instrument for ameliorating environmental problems in Nigeria.

Lipford and Yandle (2010) studies comprise of G8 and five developing countries found that there is no relationship between a global decline in CO_2 emissions and upward movement in income. Omojolabi (2010) investigated the relationship between environmental quality and economic growth in selected West African countries using panel data over the period, 1970 to2006. The paper employed the SGEKC hypothesis. The result from the pooled OLS results were consistent with the core SGEKC. On the other hand, the FE results for selected West African countries was inconsistent with the core SGEKC. Narayan and Narayan (2010) verified the existence of the core SGEKC hypothesis for 43 developing countries between 1980 and 2004. The test of the core SGEKC hypothesis was anchored on the short- and long-run income elasticities vis-à-vis CO_2 emissions. The result implies that whenever there is a minor presence of long-run income elasticity over the short-run income elasticity that represents a strong indicator that reduced CO_2 emissions would suffice under an increased income space. The result was demonstrated for Middle East countries. Jaunky (2010) tested the EKC hypothesis for 36 high-income countries (including three MENA countries: Bahrain, Oman, and UAE) between 1980 and 2005. The study a short-run and long-run unidirectional causality emanating from real per capita GDP to per capita CO_2 emissions. The empirical analysis based on individual countries suggests that for Oman (and for other six non-MENA countries), as well as for the whole panel, CO_2 emissions fell as income rose in the long run. Therefore, a one percent rise in GDP produces a 0.68 percent rise in CO_2 emissions in the short run and 0.22% in the long run for the panel. These results do not provide evidence to support the veracity of the SGEKC hypothesis but indicate that over time CO_2 emissions are stabilizing in high-income countries.

Sari and Soytas (2009) investigate the relationship between carbon emissions, income, energy, and total employment in five selected OPEC countries (including two MENA countries: Algeria and Saudi Arabia) for the period 1971 to 2002. They mainly focus on the link between energy use and income. Employing the autoregressive distributed lag (ARDL) approach, they find that there is a co-integrating relationship between the variables in Saudi Arabia and conclude that none of the countries needs to sacrifice economic growth to decrease their emission levels. Omisakin (2009) investigated the relationship between economic growth (proxy by GDP per capita) and environmental quality (proxy by CO_2) in Nigeria using annual data spanning 1970 to 2005. The study adopted the core SGEKC hypothesis. The result shows that there is an absence of long-run causality between GDP per capita and CO_2 emissions per capita. Furthermore, the result is inconsistent with the core SGEKC hypothesis depicted by a U-shaped association. The study concludes that with an increase in GDP per capita, CO_2 per capita shows an initial declining response and upward response afterwards. Coondoo and Dinda (2002) used CO_2 and found similar results that in developed countries causality runs from emissions to income while in developing countries there is no significant relationship. To buttress this, Villanueva (2012) assessing the impact of institutional quality on the environment by employing world governance indicators (WGI) of the World Bank found support for the SGEKC hypothesis using CO_2 emissions as a measure of environmental change for the period 1985-2005. Furthermore, Ravallion et al. (2000) pointed out that development processes that are essentially resource-driven will depend on how well a society manages its resources in order to avoid or encourage pollution. Panayotou (2000) investigates the role that policies and institutions play in influencing the environmental quality and discovered that better governance and policies make a moment improving environmental quality. Thus, policies and institutions that focus on development will also affect environmental pollution. The role of strengthened institutions in reducing the environmental impact of multinational corporations has recently been stressed by Osabuohien et al. (2013) that environmental hazard occurs at a diminishing rate after strong environmental policies are implemented. Evaluating the robustness of diverse parametric analyses conducted and using alternative emissions data, Galeotti et al. (2006) find that the core SGEKC does not depend on the source of data with respect to CO_2 and provide evidence of the core SGEKC for the Organization for Economic Co-operation and Development (OECD) countries but not for non-OECD countries.

Webber and Allen (2004) employed the core SGEKC hypothesis found that economic growth eventually leads to attaining both environmental and economic goals, whereas pro-environmental policies just slow down the economic growth which disrupts macroeconomic stability. Rothman (1998) employed a diversity of environmental indicators find that CO_2 emissions and metropolitan waste do not tend to fall with an upward trend in per capita income. Cole et al. (1997), List and Gallet (1999), Moomaw and Unruh (1997), and Roberts and Grimes (1997) found out that SGEKC is highly dependent on functional forms and that omitted variables could also tend to affect the shape of the curve. This is consistent with the works of Harbaugh et al. (1998), Hilton and Davidson (1998), Galeotti and Lanza (1999), Koop and Tole (1998), etc.

Some Stylized fact on Climate Variability and Issues in Development

The subject matter of shocks and pro-cyclical effect are among the major stylized facts in the development-climate change debate. Unpredictable climate patterns stifles economic parameters in terms of misallocation of which creates poverty, famine crises, starvation and hunger, and inequality problems, through the physical and transition risks channels. Extreme poverty hovers between 9.1% and 9.4% of the world's population in 2020. According to Khoday and Ali (2018), one-third of the global population is poor or near-poor and faces consistent threats to survival. Of course, policy discussion is skewed toward climate variability and insecurity, among other factors influencing the dynamics of poverty in Sub-Saharan Africa (SSA). Often unpredictable climate patterns are explained by the dynamic inevitability of emerging rainfall, flooding, famine, etc. The effect of changing climate hazards and other exposures connote that the world's poverty rate could be about 7% or more by 2030.

Since the end effect of climate vulnerability leads to poverty, climate vulnerability poses a serious socio-economic threat to the stability of the Sub-Saharan Africa. More troubling is the depleting global dimension of climate variability as well as how susceptible economic parameters faces. These twin problems i.e., climate vulnerability and poverty have been evidenced to have mutually integral, inclusive, and interdependent dimensions. Smith et al. (2021) link the climate-poverty nexus through conflicts by their impact on retarding political, economic, and social conditions. Therefore, the climate vulnerability and development linkage create a pervasive and stimulant nexus that cause poverty and disrupt development.

Scholars are extremely concerned with the transmission effects emanating from climate change to poverty, as well as how climate change could cause development reversals (United Nations Department of Economic and Social Affairs, 2016). It is important to realize the important developmental puzzle in the climate vulnerabilities and growth nexus. Economists have linked carbon emission control policy to causing poverty because of the significant impact carbon emission control policy has on energy mixes used for generating power for the industries that contribute to gross domestic product (GDP). So, at the end thereof, a carbon emission reversal policy on energy mix transmits productivity shocks that affect poverty reduction strategy and widen inequality gaps through GDP and FDI inflow. This implies that carbon emission policy causes productivity shock and income shock that worsen poverty (Hallegatte et al., 2016) and inequality indices (Islam and Winkel, 2017).

On the other hand, high poverty and inequality threaten mitigation and adaptation that could seamlessly lead to climate vulnerability reversal (Hallegatte et al., 2018). The task of reducing climate change and poverty jointly is at the center of development discourse. Two important poverty reduction strategies adopted by low-income countries are by improving and accelerating inclusiveness. Carbon emissions and incomes differ between high-income countries and low-income countries in terms of industrial contribution to GDP. Carbon per person and ecological emission is driven by income concentration, with the concentration of income potentially being a threat to mitigation, compliance, adaptation, and enforcement (Caron and Fally, 2018). The literature shows an increasing functional relationship between emission and income inequality through differential exposure and vulnerability. However, the net increase in emissions remains a contention in the literature arising from rising emission-rising income in a developed country and rising emission-lowering income in developing countries as well as defined by poor people's emissions higher than a decrease of consumption by rich people. The empirical link shows that emissions increase more slowly than income in most developed and middle-income countries.

According to Guterres (2021a), climate shocks and the COVID-19 pandemic are increasing threat to humanity. The compounding forces of the COVID-19 crisis, conflict, and climate variability e.g., flooding and temperature (proxy CO_2 concentration) impact negatively on development drivers (World Bank, 2020). By this reality, the socio-economic consequences of climate hazards connote that the dimension of climate variability manifests in many ways through the increased volatility of extreme weather events (Eckstein et al., 2021). Devereux (2007) posits that extreme weather events produce weather shocks that trigger a sequence of entitlement failures. The new realm of global food insecurity shows that climate invariability is one of the chief drivers (Saina et al., 2013).

Also, hunger's (other dimensions of poverty) resistance to policy sequencing targeted at rationalizing global resources is the most profound moral contradiction of our age (Cohen and Reeves, 1995). Guterres (2021b) contends that over 30 million people are 'just one step away from a declaration of famine. Bucher (2021) people are being starved. Beasley (2021a, 2021b) the head of the World Food Program estimates over 16 million people in Yemen are now plagued with crisis levels of hunger. In 2020, one in nine people were estimated to be hungry or undernourished while 149 million children under the age of five years are still affected by stunting globally (Global Nutrition Report, 2020). At the end of 2020, over 88 million people suffered acute hunger due to unpredictable dynamism. Between 2018 and 2019, the incidence of undernourished people due to food insecurity grew by 10million, and there are nearly 60 million more undernourished people now in 2014. Much more, over 690 million people still go hungry which is 8.9 percent of people globally. UN Report identified conflict as a major drive to hunger (Action against Hunger, 2020a, 2020b). Conflict is to a large extent influenced by climate variability (Burrrows and Kinney, 2016; Smith et al., 2021).

Scholars are unanimous about the noticeable causality existing between consequences of climate variability-global warming and flooding-food insecurity. The dimension of this logic underpinning this causality exposes the climate-flood risk-poverty causality to further studies based on the emerging reality of climate change (greenhouse gas emission) incidences. The emerging trends show that flooding, rising temperature, and appreciable sea level are perceptibly related to the impact of greenhouse gas (GHG) emissions. GHG emissions properties affect both the human and non-human components that make up the agricultural system (Tol, 2002, 2009). This is because exposure, susceptibility, and management of climate hazards depend on the prevailing structural inequalities governing the societal arrangement (World Economic Survey, 2016). Flooding, therefore, becomes a threat to the achievement of SDGs to end poverty (Del Ninno et al., 2003). The consequences of flooding affect national economies (Nordhaus, 2006, 1991) and labour market (Mueller and Quisumbing, 2011) driving upward the trend of poverty (Del Silva and Kawasaki, 2018). Another paradox aside from the climate change-poverty causality is the revelation that agriculture and food processing account for 19%-29% of global anthropogenic GHG emissions, emitting 9,800-16,900 megatons of CO_2 equivalent (Vermeulen et al., 2012). Thus, the policy's impact to stimulate mechanized farming and other measures to reduce poverty produce radioactive effects and anthropogenic changes in atmospheric composition which in turn increase CO_2 concentration and GHG emissions (Milly et al., 2002). The concern on the tripartite nature of climate pattern generates high temperature and flooding that erupts in food insecurity which leads to developmental trauma through increasing agricultural (food) prices and thereby forces households to decline in calories, crop losses, and water contaminations (Pacetti et al., 2017). Climate variability causes vulnerability in food security and generates agricultural losses due to flooding. This scenario creates social tension, threatens social survival, impedes sustainability, and threatens climate change adaption (mitigation) strategies (Adger, 2006; Smit and Wandel, 2006).

On the whole, the forces of climate change continue to trigger cycles of higher income inequality, lower social mobility, disrupt labor productivity, and lead to lower resilience for LIC to managing future shocks and diminished shared prosperity (Olsson et al., 2014; Skoufias, 2012; The fifth Assessment Report, 2015). In terms of hampering adaptation, the inestimable food insecurity-poverty-generated phenomenon crashes socio-economic policy on inclusiveness (D'Souza and Jolliffe, 2012, 2013) as more and more people become economically disadvantaged due to the vulnerability of climate variability (Oskorouchi and Sousa-Posa, 2021). Thus, the susceptibility due to the low productivity per capita leads to a harsh social survival instinct that reverses climate change control measures. The poverty-ridden community is averse to adaptation and mitigation strategies. Another channel through which climate variability impedes development is premised on the fact that higher climate variability leads to higher flooding, higher flooding leads to food insecurity, and food insecurity, in turn, food insecurity causes instability that increases poverty incidences (De Silva and Kawaski, 2018). Stern (2006) report complements the World Bank study of 2008 on the potential impacts of climate variability on poverty and development. The linkage between climate variability and human development is captured in Carvajal-Velez (2007), IPCC (2015), United Nations Economic Commission for Africa (2010), and World Bank (2020).

DATA AND METHODOLOGY

Data

Secondary data sourced from world development indicators between 1970 and 2019 was employed for this study. The data is time series data and applied to an unbalanced panel study.

Theoretical Framework

This study is anchored on the PAT (population, affluence, and technology) climate model using the Hallegatte et al. (2014) channels. However, in a more empirical estimation, the PAT model is further decomposed to reflect the condition that is amendable to allow the application of the EKC framework. EKC's is derived from Eq. (1). Thus, FGKC is given as

inequality=*f*(economic development) (1)

However, the core SGEKC states that

pollution=*f*(square and cubic GDP per capita) (2)

The core SGEKC regression conceptualized by Grossman and Krueger (1991) is given, as follows:

$$\left(E/P\right)_{it} = \alpha_i + \gamma_t + \beta_1 In\left(GDP/P\right)_{it} + \beta_2 In\left(GDP/P\right)_{it}^2 + \varepsilon_{it}, \quad (3)$$

where E is emission, P is population, GDP is gross domestic product, In indicates natural logarithm. α_i, γ_t represents intercept parameters which vary across countries or region i and years t.

The prevailing assumption is that emissions per capita may differ over countries at any particular income level (Stern, 2004). The turning point where emissions or concentration are at maximum is given as $\tau = exp\left(\frac{-\beta_1}{2\beta_2}\right)$.

Eq. (3) has been expanded, as follows:

$$\left(E/P\right)_{it} = \alpha_i + \gamma_t + \beta_1 In\left(GDP/P\right)_{it} + \beta_2 In\left(GDP/P\right)_{it}^2 + \beta_2 In\left(GDP/P\right)_{it}^3 + \varepsilon_{it} \quad (4)$$

Based on the warning issued by UN Secretary-General Antonio Guterres (2020), core SGEKC is transposed by rearranging the LHS and RHS function to obtain the transposed SGEKC. Transposed SGEKC is given, as follows:

Dev. Driv. (GDPC and ODA)=*f*(square and cubic climate patterns, μ), (5)

where Dev. Driv. is development drivers, μ is the stochastic or disturbance term, and μ~(0,1).

Eq. (5) is premised on the existing literature concern on poverty and climate change nexus. Leichenko and Silva (2014) posit that climate change and hunger, inequality, and poverty (HIP) channels are complex, multifaceted, and context-specific. Evidence suggests that climate change and HIP operate in a vicious cycle through the pattern of exposures and structural vulnerability. Hallegatte et al. (2018) assert that "the link between poverty and climate vulnerability goes two ways namely; poverty is one major driver of people's vulnerability to climate-related shocks and stressors, and this vulnerability subjectively sets people on poverty." However, Baulch (2011) viewed poverty reduction as a process largely driven by asset accumulation.

But, Barbier and Hochard (2018) demonstrate that cities with poor biophysical settings or lack of market access have a lower elasticity of poverty reduction with respect to growth, which implies that inclusive and robust economic growth is required to attain the same level of poverty reduction. Moser (2008) suggests that health shocks are the prominent channels why people fall into poverty. Arent (2014) doubt the measure of GDP as an acceptable measure to account for the distribution impact and economic cost of climate change.

The assessment of shock waves by Hallegatte et al. (2017) aligns with Krishna (2006) that poverty shocks (vulnerability) are generated directly or indirectly from the environment and climate. One of the causes of climate-related shock that causes poverty is natural risks e.g., a drought that makes investment risky and causes depletion of natural capital, fiscal shocks, and misallocation of funds (Elbers et al., 2007). A previous study by Hallegatte et al. (2014) identified price, assets, productivity, and opportunities channels linking poverty and climate variability.

From the foregoing analytical framework, the channels connecting poverty and climate change could be decomposed into direct and indirect channels. The statistical properties of weather events, flooding, and health-related issues have been found to affect poverty by lowering productivity and GDP per capita through depressed crop yields link to rising sea levels, heat waves, super storms, and transitory risks. Through transitory risk, the mitigation of emissions also leads to a decline in firms manufacturing activities that in turn bring about negative growth hence poverty. The overarching problem is that manufacturing firms that create externality effects such as pollution and CO_2 emission that cause climate change that depletes household financing for health-related diseases. The foregoing reasoning is premised on the fact that compromise required benefits to reduce carbon emissions has an economic cost which is poverty and inequity.

GDP per capita affect poverty and inequality. Statistically, the trend of poverty and inequality especially in Sub-Saharan African has reached a tipping point. One, therefore, wonders about the contributions of climate change on poverty and inequality? Human Development Report (2019) states that inequality thrives as climate change, emissions, and policy become critical. Climate change is a critical driver to the defining global inequality wave as a product of choice and not inevitabilities. Higher household incomes are associated with higher emissions, but the impact of inequality on aggregate emission depends on how quickly emissions increase as income rises.

Owing to the foregoing linkages this paper seeks to examine the impact of quadratic polynomial climate patterns (proxy by CO_2 emission) on development drivers (proxy by GDP per capita and ODA through the revised-EKC model. This study builds on two of the channels identified by Hallegatte et al. (2016). These channels are prices, assets, productivity, and opportunities channels. In this study, income per capita (*GDP/P*) (a proxy for productivity) and *ODA* (a proxy for assets) in the Hallegatte et al. (2016) channels.

Model Specification

The unbalanced panel data approach method employed pooled mean group (PMG). According to Pesaran et al. (1998), PMG/panel ARDL takes the co-integration form of the simple ARDL and adapts it for a balanced panel setting by allowing intercept, short-run, and co-integrating terms to differ across cross-sections. PMG decomposes the coefficient into long-run and short-run coefficients. General, the PMG model is given, as follows:

$$\Delta y_{i,t} = \emptyset_i EC_{i,t} + \sum_{j=0}^{q-1} \Delta X_{i,t-j}\,,j'\beta_{i,j} + \sum_{j=1}^{p-1} \gamma_i\,,j^{*}\Delta y_{i,t-j} + \varepsilon_{i,t} \quad (6)$$

where $EC_{i,t} = y_i, t-1 - X_i, t'\theta$.

Pesaran et al. (1988) adopted ARDL (1, 1, 1) model for balanced panel analysis. It is clear from the PMG/ARDL model that the dependent variable and the regressors have the same number of lags in each cross-section. The long-run coefficient θ and the adjustment coefficients $\emptyset$ are further defined in the log-likelihood function (Pesaran et al., 1998).

Pesaran et al.'s (1998) PMG model in Eq. (7) is modified to become amendable with the TSGEKC framework that permits climate variability and development drivers nexus. The panel model for this study is given, as follows:

$$logDevD_{it} = f(logCCP_{it}, \mu_{it}) \quad (7)$$

$$\Delta logDevD_{i,tm1-6} = \emptyset_i EC_{i,t} + \beta_1 logCO2^1_{i,t-1} + \beta_2 logCO2^2_{i,t-1} + \beta_3 logCO2^3_{i,t-1} + \beta_4 logPOP_{i,t-1} + \gamma_i logDevV_{i,t-1} + \varepsilon_{i,t}$$

$$EC_i, t = logDevV_i, t-1 - X_i, t'\theta \quad (8)$$

$$\Delta logGDPC_{i,tm1-6} = \emptyset_i EC_{i,t} + \beta_1 logCO2^1_{i,t-1} + \beta_2 logCO2^2_{i,t-1} + \beta_3 logCO2^3_{i,t-1} + \beta_4 logPOP_{i,t-1} + \gamma_i logGDPC_{i,t-1} + \varepsilon_{i,t}$$

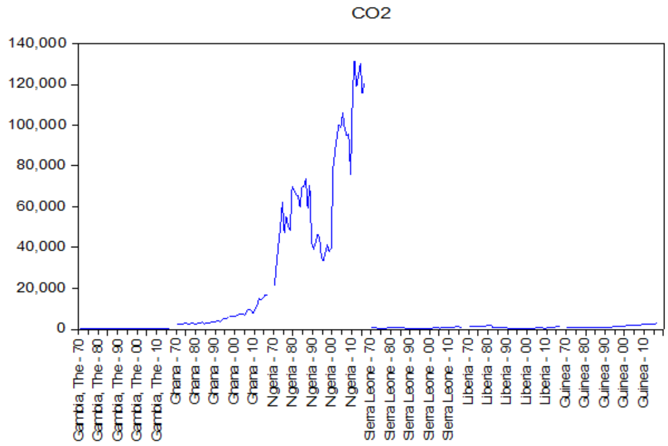

Figure 1. Relationship between CO_2 and ODA in WAMZ, 1970-2019:I

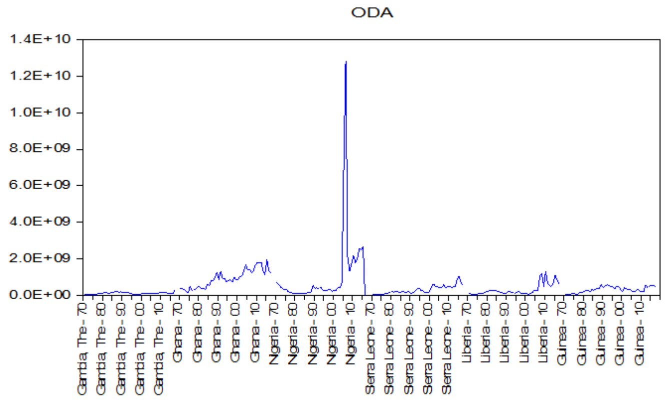

Figure 2. Relationship between CO2 and ODA in WAMZ, 1970-2019:II

$$EC_i, t = logGDPC_{i,}, t-1 - X_i, t'\theta \quad (9)$$

$$\Delta logODA_{i,tm1-6} = \emptyset_i EC_{i,t} + \beta_1 logCO2^1_{i,t-1} + \beta_2 logCO2^2_{i,t-1} + \beta_3 logCO2^3_{i,t-1} + \beta_4 logPOP_{i,t-1} + \gamma_i logODA_{i,t-1} + \varepsilon_{i,t}$$

$$EC_i, t = logODA_{i,}, t-1 - X_i, t'\theta \quad (10)$$

Apriori expectation $\beta_1 > 0, \beta_2 < 0, \beta_3 > 0, \beta_4 > 0$, where, *CCP* =climate change patterns, *DevD* =development drivers, *GDPC* =income per capita, $CO2^1_{it}$ =first stage CO_2 emission, $CO2^2_{it}$=second stage (square) CO_2 emission, $CO2^3_{it}$=third stage (cubic) CO_2 emission in WAMZ FDI=foreign direct investment, *POP*=population, *ODA*=official development assistance, *i*=WAMZ, *t*= time, 1970-2019, β_1, β_2, β_3, β_4 are parameters, μ stochastic terms, m1=the Gambia, m2=Ghana, m3=Nigeria, m4=Sierra Leone, m5=Liberia, and m6=Guinea, Δ =the difference, *EC*=speed of adjustment, and log=logarithm.

Estimation Procedure

Diagnostic analyses were conducted to lessen the apparent trend in the hypothesized variables in **Figure 1**, **Figure 2**, **Figure 3**, and **Figure 4**. From the pictorial illustration, there is evidence of a trend in the WAMZ environment. Furthermore, the panel ADF test (Levin, Lui and Chu t*) guarantees the non-existence of spurious variables after differencing at *I*(1). **Figure 1**, **Figure 2**, **Figure 3**, and **Figure 4** rationalize the

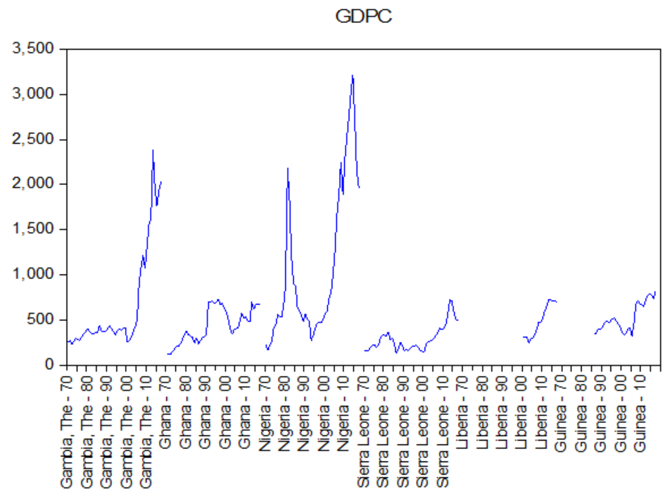

Figure 3. Relationship between GDPC and POP in WAMZ, 1970-2019:I

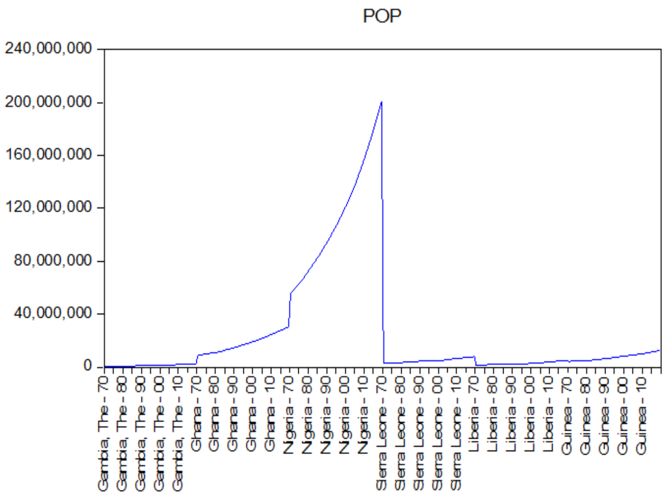

Figure 4. Relationship between GDPC and POP in WAMZ, 1970-2019:II

basis for the adoption of an unbalanced panel study in this study.

The cross-section dependence (CSD) using the Breusch-pagan LM tests at 5% connotes the presence of inter-relationship existing within the WAMZ region. This paper employed the Hausman test to determine the appropriate model specifications for Eq. (9) and Eq. (10). Given that Ho: random effect is efficient and Ha: fixed effect is efficient. The Chi-square statistic at 5% depicts that the random effect model is suitable, hence the study employed the pooled mean group (PMG) method. Panel cointegrations to determine the long run relationship using trace test and max-Eigen test depict, the null hypothesis is rejected that co-integration exists.

RESULTS AND DISCUSSION

Table 1 provides the PMG result for two models namely; the income per capita model (LogGDPC) and official development assistance (LogODA) models expressed in Eq. (9) and Eq. (10), respectively. The PMG result in **Table 1** gives an

Table 1. Pooled mean group (PMG) results

Variable	LogGDPC (Eq. 9)	LogODA (Eq. 10)
Long run equation		
	Coefficient (Prob.*)	
LOGCO2	10.86658 (0.0018)	-17.64855 (0.0015)
LOGCO22	-2.744168 (0.0038)	5.435250 (0.0018)
LOGCO23	0.239948 (0.0039)	-0.551657 (0.0021)
LOGPOP	0.456622 (0.0228)	1.862062 (0.0000)
Short run equation		
COINTEQ01	-0.287355 (0.0001)	-0.362825 (0.0000)
D(LOGGDPC(-1))	0.132081 (0.3061)	-129.2268 (0.2014)
D(LOGCO2)	-75.39290 (0.1539)	36.25582 (0.2269)
D(LOGCO22)	24.69395 (0.1401)	-3.525325 (0.2501)
D(LOGCO23)	-2.704388 (0.1287)	9.052492 (0.0426)
D(LOGPOP)	12.12333 (0.0969)	5.199708 (0.0000)
C	-4.465517 (0.0001)	-0.362825 (0.0000)

Note. Source: Author's computation from Eviews 9

insight into the short-run and long-run impact of the changes in climate variability (regressor) on the GDPC and ODA (regressand) in WAMZ, respectively. The foregoing panel result illustrates that there is a 28.7% and 36.2% speed of adjustment from short-run to long-run. This implies that given any perceptible change in the Eq. (9) and Eq. (10) the system would find its long-run space from short-run dynamism at an average speed of 21.6%. From short-run results, the impact of CO_2 emissions is not statistically significant at a 5% level of significance (LOS) for GDPC and ODA except for the cubic CO_2 emissions impact on ODA with p-values of 4.26%. In the short-run, first stage CO_2 emissions led to a massive decline in GDPC while ODA into WAMZ improved. Second and third stage CO_2 emissions changes affected GDPC and ODA in no less measure. But in the long-run, CO_2 emission's impact on the development drivers are significant. A percent change in first stage CO_2 emissions, second stage CO_2 emissions, and third stage CO_2 emissions causes a positive, negative, and positive impact on GDPC as well as leads to a negative, positive, and negative impact on ODA. This implies that any perceptible change in climate variability (represented by first, second, and third stage CO_2 emissions) causes a 1086.6% rise, 274.4% drop, and 23.9% rise in GDPC. Similarly, a percent change in CO_2 emissions brings about a drop of 1764.8%, an increase of 543.5%, and a decline of 55.1% in ODA. The turning point at which emission is concentrated for Eq. (9) and Eq. (10) is represented as $\tau = exp\left(\frac{-\beta_1}{2\beta_2}\right)$ by substitution this study obtains 7.2424 and 5.0711, respectively. These values showed the turning point where emissions or concentration are at maximum for the GDPC model and ODA model.

CONCLUSION AND POLICY RECOMMENDATIONS

Specifically, utilizing the transposed SGEKC, the result found a long-run N-shaped relationship between climate patterns (proxy by CO_2 emissions) and GDPC (proxy by income per capita) in WAMZ. Also, in the long run, the impact of CO_2 emissions on ODA produced an inverted N-shaped relationship. The N-shaped in the transposed SGEKC implies that unpredictable patterns causes fluctuation in income growth rate. Thus, climate changes could increase long-run growth due to shifts in market conditions and structural changes. Also, the result implies that worsening environmental conditions could limit income growth but over and above certain absorptive capacity, growth in GDP per capita is guaranteed. Specifically, in strict sense, the signs of the results are very important in the nature and shape of the impact of climate variability on the income growth which could translate to vulnerability in WAMZ and in turn accentuate the susceptibility of region to physical and transitory risks. The result connotes that as climate variability in WAMZ increases; GDPC increases, decreases, and afterwards increases. Additionally, climate variability is inversely related to ODA inflow into WAMZ in the long run. Unlike, the positive relation between CO_2 emissions and long-run GDP per capita, CO_2 emissions has a negative relationship with ODA in the long run. The economic interpretation to this result shows that ODA is sensitive to climate changes but suggest the absence of pollution haven problem within the WAMZ. So, therefore, ODA inflows into WAMZ is expected to decline as climate patterns worsens. Thus, this paper therefore, recommends an effective fiscal policy to mitigate the impact of CO_2 emissions on GDPC and to deepen the adoption of green financing to ensure that the imperative for attracting ODAs into WAMZ is enable GRIS development rather than enhance inflow of polluting multinational enterprises (MNE) that take advantage of lax environmental system. There should be effective monitoring using the IPCC methodology to

a. predict the extent and magnitude to which shock from climate change can cause vulnerabilities in households and firms' objective function in order to avoid developmental reversal caused by changing climate patterns and
b. as well as to improve the WAMZ's NDCs targets.

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