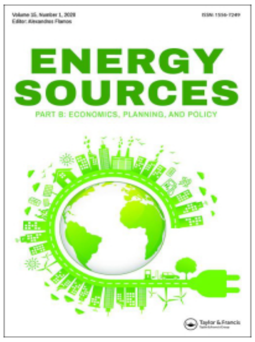

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Inclusive growth and the sophisticated influence of carbon emissions, renewable energy, and financial development: An introspective analysis of Africa

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ABSTRACT

This study investigates how inclusive growth is affected by carbon emission, renewable energy, and the new financial development index using 48 African countries categorized into low-income countries (LIC) and middle-income countries (MIC) spanning from 2000 to 2018. Bearing in mind the presence of residual cross-sectional reliance and heterogeneity in a panel data settings, the study employed robust estimations econometric approaches which includes the Augmented Mean group (AMG), Driscoll-Kraay (DK) standard errors method together with the Correlated Effects Mean Group (CCEMG) technique. The study's outcomes from the mentioned approaches showed that; carbon emission positively affects inclusive growth in aggregate African panel, and LIC but not in MIC panels correspondingly. Furthermore, renewable energy significantly mitigates inclusive growth in LIC group African nations, but not significant in Africa as a whole or in MIC country grouping. Financial development is homogeneously positive and significant, with inclusive growth across all panels of African economies. The outlined outcomes were also confirmed by the Generalized Method of Moments (System-GMM). Based on the outlined study preferably suggest that carbon emission in LIC must be focused on attracting investments with low carbon footprints. On renewable energy, it is further recommended that both LIC and MIC should sticks to the African Renewable Energy Initiative.

KEYWORDS

Africa; carbon emission; financial development; inclusive growth; renewable energy

1. Introduction

In the case of unvailing the link between carbon (CO_2) emissions, renewable energy, and growth aids economies in implementing sustainable energy policies and developing energy resources, CO_2 emission levels are evidenced to be strongly influenced by social, geopolitical, and industrial factors, which directly affect growth around the globe (Dauda et al. 2019; Maji, Sulaiman, and Abdul-Rahim 2019; Musah et al. 2020). As the idea about having sustainable/renewable energy liaised with growth may differ from one sub-region to another, financial sector development can also play a key role (Işik, Kasımatı, and Ongan 2017; R. Wang et al. 2020). The idea of growth is mainly interpreted from the point of economic growth. The key economic challenge most African countries face is how to make economic growth more inclusive. In harmonizing economic growth and high standard of living, there must be a paradigm shift from economic growth literature to inclusive growth studies (Ali and Son 2007; Anand, Mishra, and Peiris

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2013). In executing the UN's sustainable development goals agenda for the foreseeable future, policymakers have agreed that eradicating poverty, driving sustainable energy policies,together with creating peaceful and inclusive communities is central to creating a better life for all people (Kouton 2020; Maji 2019).

Considering the afore-said assertions this extant study focuses on how CO_2 emission, renewable energy, and financial development impact inclusive growth in Africa. A distinctive feature of this study is concentrating on inclusive growth and not on economic growth. Over the years different studies have been conducted in relation to economic growth in Africa (Appiah, Li, and Frowne 2020; Kong et al. 2020; Korankye et al. 2020; Nketia and Kong 2021) but for inclusive growth in Africa, it is rarely studied.

The study therefore makes novel contributions to literature in five main folds: First, to unveil the impact of CO_2 emission on inclusive growth in Africa, via the income levels of African economies. Secondly, to disclose the influence that renewable energy has on inclusive growth in Africa, considering the income levels of African economies. Further, this extant study innovatively investigates the impact of Svirydzenka's (2016) financial development index on Africa's inclusive growth, taking into consideration the income levels of Afircan economies. Specifically, earlier studies have classified employed countries into regional and/or sub-regional blocs; nonetheless, this study, splits the economies into two sub-groups; low-income countries (LIC) and lower & upper-middle-income countries (MIC), according to the classification by World Bank (2020). By adopting this, the actual reaction of the sub-groups and the aggregate group can be understood. Finally, available related literature used methodologies like difference-GMM, FMOLS, 2SLS, EKC, and DSUR; however, this study adopted CCEMG, AMG, DK, and system-GMM for the estimations. The methodologies adopted for this study makes it robust compared to the other studies, which used one or two methodologies. The remaining study is presented in the following order; literature review, materials and methods, empirical results, discussion of results, and conclusion and policy implication.

2. Literature review

2.1. Inclusive growth in Africa

Developing economies like African countries attained high economic growth rates than most economies in Asia, Europe, and North America, yet, there are still high unemployment rates, abject poverty, and financial inequality (Nketia and Kong 2021; Obeng-Odoom 2020). High Gross Domestic Product (GDP) growth rates in developing economies are mostly beneficial to a part of the population but not the entire populace (Nketia, Kong, and Korankye 2020).

To ensure fair distribution of growth and resources, all sectors must contribute and benefit from the growth process, thus there must be inclusiveness in the growth (Kong et al. 2020). Based on that, inclusive growth may be expressed as the type of growth that aims to ensure that all social, income, and economic agents proportionally contribute their portion in the economy's growth, and share in the benefit thereof (Cordemans 2019). Anand, Mishra, and Peiris (2013) stated that the social function to ensure inclusive growth needs to satisfy two conditions; (i) it ensures constant growth (growth element), and (ii) it fulfills property transfer (distribution element); thus, any allocation of income from a poor person to a wealthier person decreases the value of the function. Nevertheless, it should be recognized that continuity or sustainability is conditioned upon inclusive growth (Raheem, Isah, and Adedeji 2018). Relying on available literature, the study followed the works of Raheem, Isah, and Adedeji (2018), Oyinlola and Adedeji (2019), Kouton (2020), Oyinlola et al. (2020), among others, and used GDP per person employed as the measure for inclusive growth. the mentioned metric fuses economic growth with employment (World Bank 2020). Inclusive growth reflects two main facets of individual economic enabling; the opportunities that are readily accessible to the large population and the allocation of those available opportunities through the different sectors (IMF 2020; World; Bank 2020).

2.2. Carbon emission in Africa

There are some growing concerns regarding the relationship between inclusive growth and CO_2 emissions. The current trajectory of carbon emission and greenhouses emission may raise the worlds' average temperature by 4°C or more by 2100 and by 1.5 to 2 times as much in several midcontinent and far northern locations (Obama 2017). Lin, Inglesi-Lotz, and Chang (2018) studied CO_2 emission in G18 countries and concluded that in 5 of the countries, there is a convergence of CO_2 and growth. Besides, CO_2 emission and other forms of emission like $PM_{2.5}$ emissions emitting from industrialization shows significant correlation with growth in mostly Asian countries (Fang and Yu 2021; Yu and Fang 2021). Arguably, economic growth in Africa is likely to have a negative impact on the environment due to high CO_2 emissions and other forms of waste caused by energy consumption, especially nonrenewable energy (Ampon-Wireko et al. 2021; Musah et al. 2020). It is estimated that energy demand will increase by 1.5% between 2015 and 2030. In effect, there will undoubtedly be an increase in CO_2 emissions in the same time frame (Pizarro-Irizar et al. 2020). To reduce the estimated CO_2 emission and simultaneously satisfy the energy need in Europe, the European Union (EU) is shifting from CO_2 emission energy generation to clean energy in the last decade (Yu, Fang, and Dong 2020).

On CO_2 emission and renewable energy, Altinoz and Dogan (2021) used quantile regressions for 82 countries and concluded that renewable energy usage decreases carbon emissions. In the case of Europe, Khoshnevis Yazdi and Shakouri (2018) used Granger causality to show no causality between renewable energy usage and CO_2 emissions. In China, Dong et al. (2021b) studied how to reduce industrial pollution (including CO_2 emissions) through Industrial Pollution Mitigation Performance (IPMP) in the various provinces. They reported that government's strict environmental enforcement had positive impact on IPMP, thus reducing industrial pollution. Nevertheless, the argument of how CO_2 emission impacts inclusive growth emanates from the background that, increase in CO_2 emission is from the use of energy (Jonkutė et al. 2021; Taşkin, Cagli, and Evrim Mandaci 2021), which proportionally influences employment and is eventually responsible for hazardous environmental problems. The relevant question is, is there any relationship between carbon emission and inclusive growth in Africa? Much attention has not been laid on carbon emission and inclusive growth, especially in Africa. This literature gap necessitates the curiosity of modern studies trends. It has become imperative to dive into Africa's concentration on the relationship between inclusive growth and CO_2 emission for policy formulation and contribution to reduce CO_2 emission. This leads to the first hypothesis of the study *H1: CO_2 emission has no impact on inclusive growth in Africa.*

2.3. Renewable energy in Africa

Lately, there is a call for absolute clean energy consumption in Africa like solar, hydropower, wind, geothermal, and biomass. Apart from the energy being clean which saves the environment, they are also cost-effective, saving the countries lots of money. When energy consumption is not controlled, it will increase carbon intensity (Pan and Dong 2022). By applying Environmental Kuznets Curve (EKC) and Dynamic Seemingly Unrelated Regression (DSUR), Saud et al. (2019) opined that renewable energy is reliable and resilient compared to nonrenewable energy sources; for instance, solar and wind energy sources are less likely to be susceptible to failure because they are widely modular and distributed. Renewable energy sources like hydropower, solar, biomass, and wind are readily obtainable in Africa (Bhuiyan et al. 2018). Also, solar energy is abundantly in the Northern African region as well as parts of Southern and Eastern Africa; for the case of geothermal energy sources, they are available in the Southern and Eastern parts of Africa; whereas wind resources of energy are also available in Northern African regions (Kouton 2020).

Yu et al. (2021) stated that in the EU, investment in renewable energy has significantly enhanced its promotion and it has enormous potential in renewable energy generation. Going by the Kyoto Protocol, industrialized economies are to reduce carbon emission significantly; for this to happen, the clean development mechanism must yield to an additional double condition of sustainable development (Fiamos, Psarras, and Samouilidis 2020). Trying to attain the emission objectives set at the Kyoto and Paris agreements, African economies need to adopt green technology and encourage energy innovation to warrant sustainable development (Saud et al. 2019). Schwerhoff and Sy (2017) stated that Africa must resolve critical energy concerns with renewable energy, reducing poverty and enhancing growth.

Previous studies on renewable energy in Africa fail to acknowledge the effect renewable energy on inclusive growth. In its attempt to look at this gap, the available literature only mildly relates it to economic growth (see; Asane-Otoo 2015; Baye et al. 2020; Nathaniel and Iheonu 2019). Therefore, what is the relationship between renewable energy and inclusive growth in Africa? Clearly, the literature vacuum on renewable energy's impact on inclusive growth in Africa needs to be filled. As it currently stands, policymakers and the research community have been denied knowledge of how inclusive growth relates to renewable energy in Africa. Knowledge of the relationship between inclusive growth and renewable energy will significantly shape energy policy direction in Africa. The second hypothesis of the study may therefore be stated as *H2: Renewable Energy has no impact on inclusive growth in Africa*

2.4. Financial Development in Africa

Comprehensive studies have been conducted in the area of economic growth and financial development; most of these studies hover around the finance-led growth (supply-leading) theory and growth-led finance (demand-following) theory (see; Appiah, Li, and Frowne 2020; Efogo 2020; Kong et al. 2020; Nketia and Kong 2021; Nketia, Kong, and Korankye 2020) predominantly a positive and bi-directional relationship was found between them. The critical role of financial development in the advancement of an economy cannot be downplayed. However, there is a need to concentrate on inclusive growth and financial development since mere economic growth does not necessarily reflect a higher standard of living. In effect, inclusive growth is more meaningful in the development program than just economic growth. By employing difference-GMM, Ntow-Gyamfi et al. (2019) emphasize the need to have an effective institutional setup to control the financial market participants' inclusiveness. In addition, Singh (2017) used Fully Modified Ordinary Least Squares (FMOLS) and stated that inclusive growth occurs when a group of people have played their part in the growth of an organization/economy and have benefitted proportionately from it.

The available literature on financial development uses a proxy of financial development like broad money-to-GDP ratio, private sector credit-to-GDP ratio, or z-score capital adequacy ratio, which measures some aspects of financial development. Svirydzenka (2016) has compiled financial development index for the international monetary fund (IMF), which considers all aspects of financial development. To put it into perspective, the new financial development index is an amalgamation of depth (market size and liquidity), access (financial service availability to entities), and efficiency (sustainable, affordable financial services, and capital market activity level); financial sustainability is imbedded in financial efficiency (IMF 2020; Svirydzenka 2016). So how does this new financial development index related to inclusive growth in Africa? Therefore, there is the need to ascertain the impact of the new financial development index and inclusive growth, especially in Africa, since the policy director of the continent may depend on such knowledge. The final hypothesis of the study is *H3: Financial development has no impact on inclusive growth in Africa.*

3. Material and Methods

This section discusses the variables, general data, the empirical econometric model, and the econometric approach for the study. The section further gives detail about model estimation and robustness check.

3.1. Material (Variables)

Data employed for this study cover the period 2000–2018; this specific time span was selected due to data availability for countries under the study. The study covers 48 countries in Africa. The countries are further separated into two categories; LIC and MIC.[1] The countries under the study has also been represented on a GIS map in Figure 1. The classifications were done using the World Bank's grouping of countries by income levels.[2] The panel data employed were obtained from different sources concerning the study variables. Appendix B, therefore, outlines the summary of variables descriptions together with their respective data sources.

In detail, the study considers Gross Domestic Product (GDP) per person employed as our measure of inclusive growth (World Bank 2020). IThe mentioned variable is used to evaluate a country's economic capability to generate and sustain acceptable work prospects with reasonable and just remuneration. This database is attained by computing the weighted average of labor data from the International Labor Organization, and GDP from the World Bank. Inclusive growth represents two vital aspects of individual economic enablement; the opportunities readily accessible to the broad

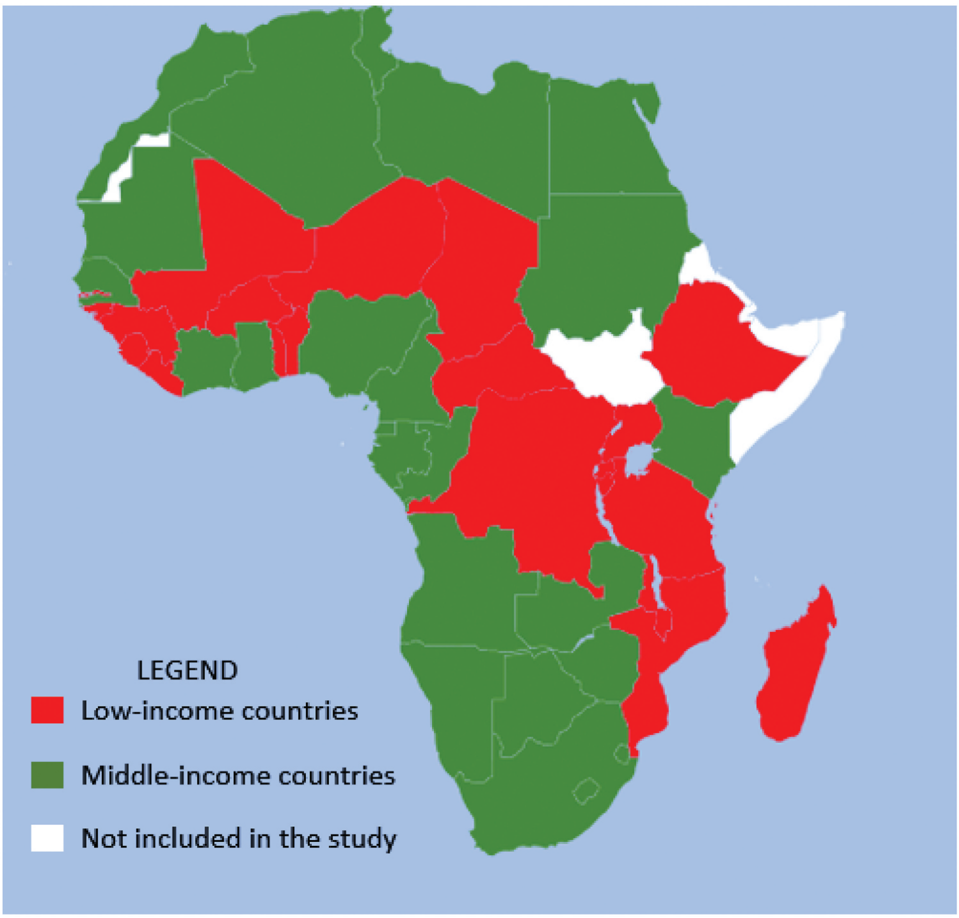

Figure 1. Income distribution of Countries under the study.

[1]List of countries under the study as well as, LIC and MIC groups are in Appendix A
[2]Groupings of LIC and MIC are based on World Bank's groupings (World Bank 2020)

population and how those available opportunities are distributed across the various sectors (Kouton 2020; Oyinlola and Adedeji 2019; Raheem, Isah, and Adedeji 2018). The United Nations also use the proxy to monitor the eighth Sustainable Development Goals (SDGs). Further Carbon emission is measured as the percentage of total final liquid fuel consumption (Asane-Otoo 2015; Dong et al. 2021a; Thonig et al. 2021; R. Wang et al. 2020). In addition, renewable energy consumption is measureed as the proportion of total final energy use. It consists of hydroelectric and total non-hydroelectric renewables like wind, tide and wave, waste, solar, geothermal, and biomass (Altinoz and Dogan 2021; Kouton 2020; Maji, Sulaiman, and Abdul-Rahim 2019). The financial development index by Svirydzenka (2016) was adopted as well for the study; it is the first principal component of two sub-indexes; financial markets and financial institutions. The three components considered financial depth, access, and efficiency in computations make the study's index robust (Efogo 2020; Ouyang and Rajan 2019; Oyinlola and Adedeji 2019). The other control variable used in the study are; gross capital formation, and foreign direct investment (Aluko and Ibrahim 2020; Chakroun 2020; Ibrahim and Alagidede 2018; Kouton 2020). All the variables were transformed into a natural logarithm for the consistency of measurements.

3.2. Empirical Model

This current study empirically estimates the effect of CO_2, renewable energy, and financial development on inclusive growth, using the Cobb-Douglas production function expressed as:

$$Y = AK^{\alpha_1}L^{\alpha_2} \tag{1}$$

where Y denotes output, A indicates technological improvement, K represents capital and L connotes labor. In addition, α_1 and α_2 represents the elasticities of output to both capital and labor, respectively. Following previous studies (Awodumi and Adewuyi 2020; Le and Sarkodie 2020; Le and Van 2020; Musah etal. 2020) , the cobb-Douglas function can be augumentd to include renewable energy use, and labor due to the technological innovation factor, with gross capital formation representing capital 2020202020202020. Hence, our augmented Cobb-Douglas function used in this extant study is expressed as:

$$Y = f(REN^{\alpha_1}, GCF^{\alpha_2}, {CO_2}^{\alpha_3}) \tag{2}$$

where Y represents inclusive growth (ICG) whereas REN, GCF, and CO_2 denotes renewable energy consumption, gross capital formation, and carbon emissions correspondingly. Again, α_1, α_2 and α_3 represents the elasticities of output to renewable energy, gross capital formation, and carbon emission, respectively. In order to lessen issues concerning omission of variable biasness and complementarities, Foreign Direct Investment (FDI), and Gross Capital Formation (GCF) were further introduced as control variables. Hence, for the purpose of econometric estimation the linear combinations of the explanatory variables and their respective coefficients forming the extended model is formulated as

$$ICG_{it} = \alpha_0 + \alpha_1 CO_{2it} + \alpha_2 REN_{it} + \alpha_3 FND_{it} + \alpha_4 FDI_{it} + \alpha_5 GCF_{it} + \lambda_t + \eta_i + \mu_{it} \tag{3}$$

where the subscript "i" signifies the individual cross-sections, and "t" is time, whereas λ, η, andμ are the stochastic terms, respectively. Due to fluctuations and uneven units of measurements, the variables were converted into a natural logarithm. Log-linear models estimates are more robust than results from ordinary linear models. Also, log-linear models exceed simple linear models and generate unswerving estimates (Le and Van 2020; Musah et al. 2020; Shahbaz et al. 2018). From this assertion, we transformed equation (2) into a natural logarithm. Thus, the log-transform of the model expressed in equation (2) is given by;

$$lnICG_{it} = \alpha_0 + \alpha_1 lnCO_{2it} + \alpha_2 lnREN_{it} + \alpha_3 lnFND_{it} + \alpha_4 lnFDI_{it} + \alpha_5 lnGCF_{it} + \mu_{it} \tag{4}$$

3.3. Econometric approach

The panel data for the study pass through various preliminary tests before the expected results could be attained. First, the study conducted the multicollinearity test using the variance inflation factor (VIF) and tolerance tests to verify if the independent variables are highly correlated with each other or not. Further the Shapiro normality test was conducted to ascertain if the data is normally distributed or not. Aside from the multicollinearity tests and normality checks being performed, the cross-sectional dependency (CD) test was in addition executed to commence the econometric tests. Specifically, the CD test is conducted to verify the presence of residual cross-sectional correlations within the panel. Hence, the study employed the Breusch and Pagan (1980) LM test, together with the Pesaran (2004) scaled LM test, and Pesaran (2015) CD test. Bearing in mind the potential occurrence of residual cross-sectional connectedness, the study as well considered the possibility of slope heterogeneity. Precisely, a study where slope homogeneity is ignored may be detrimental to the regression analysis. Hence, to avoid possible bias regression analysis, the study adopted the Pesaran and Yamagata (2008) test to scrutinize the issues concerning heterogeneity among slope coefficients.

To continue with the econometric analysis of the study, the study further conducted a panel unit root test using second-generation techniques. The tests to be considered therefore include, Cross-sectional Im Pesaran and Shin (CIPS) panel unit root test by Pesaran (2007) and Cross-sectional Augmented Dickey Fuller (CADF) panel unit root test by Im, Pesaran, and Shin (IPS) (2003). Considering the potential existence of cross-sectional dependency within the panel, the cointegration (long-run relationship) among employed variables is further investigated via the Westerlund (2007) cointegration checks (Dauda et al. 2019). Taking into account the cointegration among the study variables, estimators which includes the Common Correlated Effects Mean Group (CCEMG) technique by Pesaran (2006), the Augmented Mean Group (AMG) technique by Eberhardt and Teal (2010), and the Driscoll-Kraay (DK) standard errors method by Driscoll and Kraay (1998) are correspondingly employed finally to estimate the long-run relationships.

3.3.1. Panel model estimation

There are several estimate approaches for panel data estimation ; however, if the data contains cross-sectional dependencies and/or heterogeneity, second-generation estimation techniques must be used (Kong et al. 2020). Using first-generation techniques in the presence of cross-sectional dependency can produce biased outcomes. Therefore, to obtain reliable and unbiased estimates, this study, as mentioned, already employs heterogeneous coefficient estimators; CCEMG, AMG technique, and the DK standard errors methods. These estimation methods not only generate consistent predicted values of panel sample averages, but they also account for a substantial degree of variability by giving country-specific slope parameters and confidence intervals for all regressors. It is crucial to highlight that, although using the same technique, the estimators differ in how cross-section dependency or standard unobservable variables with heterogeneous effects are captured.

First, the CCEMG estimator takes care of cross-sectional dependency issues to amplify the group-specific estimation function. The CCEMG method is robust, even with a restricted number of "strong" values and unlimited "weak" values. The aforementioned estimation method can deal with autocorrelation among the residuals and unit roots in the mutual factors, and as well vigorous to dependencies and slope heterogeneity (Chudik & Pesaran, 2015; Chudik, Pesaran, and Tosetti 2011; Pesaran 2006). Once again, unobservable common factors are represented by incorporating cross-sectional averages of all factors. Apergis and Payne (2011), indicated that the CCEMG is robust to non-stationary variables, serial correlation, and structural breaks. This estimator gives an outstanding performance in situations where the data has panel variability and multi-factor error terms. The linear combination of cross-sectional averages of common impacts and parameters is then used. The CCEMG function with respect to the variables employed in the study is therefore specified as;

$$InICG_{it} = \lambda_i + \Theta_1 \overline{lnCO}_{2it} + \Theta_2 \overline{lnREN}_{it} + \Theta_3 \overline{lnFND}_{it} + \Theta_4 \overline{lnFDI}_{it} + \Theta_5 \overline{lnGCF}_{it} + W_{it} + \varepsilon_{it} \tag{5}$$

where $W_{it} = \sum_{i=1}^{5} \beta_j X_{j,it}$ with β_j representing the parameter estimates of the corresponding study variables, X_j is a vector of explanatory variables, λ_i represents a constant term, Θ_i on the other hand, is the cross-sectional coefficients and ε is the error term.
According to the report made by Pesaran (2006), the slope coefficients as specified in equation (5) are averaged across the various cross-sections within a panel. Thus, with the aim of estimating the $\Theta_i{}'$ s, the CCEMG estimator ($\hat{\Theta}_i, CCEMG$) is computed using the relation:

$$\hat{\Theta}_{i,CCEMG} = \frac{I}{N} \sum_{i=1}^{N} \hat{\Theta}_i \tag{6}$$

Furthermore the AMG estimation technique was proposed by Eberhardt and Bond (2009) and developed further by Eberhardt and Teal (2010). The mentioned long-run estimation approach advances on the regular average group with the addition of the "mutual dynamic process" taken from a first difference pooled OLS estimation, which offers a panel-equivalent mean measure of the unobserved mutual factors. Considering the potential occurrence of heterogeneity within the slope coefficients and cross-sectional dependence matters, the AMG is a better estimator to use (Bond and Eberhardt 2013). Moreover, in the AMG estimation process, the collection of unobservable common variables is considered as a common dynamic process and is represented by adding coefficients of year dummies from a first differenced pooled regression. The major value of AMG regression is that it offers country-specific results and aims to accomplish more adequate policy goals. As proposed by Wang and Dong (2019), the functional type of AMG involves two-step processes. From the first stage of the AMG method, the study's proposed model as specified in equation (4) is estimated using $T - 1$ dummies in a differenced form (first difference) through the following panel regression model specified as:

$$\begin{aligned} In\Delta ICG_{it} = {} & \alpha_i + \theta_1 In\Delta CO_{2it} + \theta_2 In\Delta REN_{it} + \theta_3 In\Delta FND_{it} + \theta_4 In\Delta FDI_{it} + \theta_5 In\Delta GCF_{it} \\ & + \sum_{t=2}^{t} \phi_t (\Delta D_t) + \varepsilon_{it} \end{aligned} \tag{7}$$

where ΔD_t denotes the first difference order with $T - 1$ time dummies, $\emptyset_t$ represents the coefficients of ΔD_t, α_i is the constant term whereas $\theta_1, \ldots, \theta_5$ capture the parameter estimates of the differenced study variables.
With the second stage, the parameter $\emptyset_t$ is transformed to η_t (i.e. $\emptyset_t \equiv \eta_t$) and then express in a common dynamic process as follows;

$$In\Delta CO_{2it} = \alpha_i + \theta_1 In\Delta CO_{2it} + \theta_2 In\Delta REN_{it} + \theta_3 In\Delta FND_{it} + \theta_4 In\Delta FDI_{it} + \theta_5 In\Delta GCF_{it} + \eta_t(d_t) + \varepsilon_{it} \tag{3}$$

Where
$In\Delta CO_{2it} - \eta_t(d_t) = \alpha_i + \theta_1 In\Delta CO_{2it} + \theta_2 In\Delta REN_{it} + \theta_3 In\Delta FND_{it} + \theta_4 In\Delta FDI_{it} + \theta_5 In\Delta GCF_{it} + \varepsilon_{it}$, and d_t is represents the standard dynamic process and estimated coefficients of each dummy.

We can, therefore deduce that, the cross-section panel model with η_t as specified in equation (8) is adjusted before estimating the average parameter estimates in terms of country specifics. Thus, for each explanatory variable specified in the study's model, the parameters to estimate based on the AMG estimation method can be computed using the relation:

$$\widehat{\theta}_{iAMG} = \frac{I}{N} \sum_{i=1}^{N} \hat{\theta}_i \tag{9}$$

The AMG method considers cross-sectional dependency by applying a "common dynamic process" to the regression. This technique reveals cross-sectional dependence and offers heterogeneous coefficients of slope between members of the panel. Furthermore, as this method estimates by weighing the arithmetic mean of cointegration coefficients, it is better than other coefficient estimation methods (Kong et al. 2020; Nketia, Kong, and Korankye 2020; Paramati and Roca 2019).

Finally, the DK estimation offers common errors robust to cross-sectional and sequential dependence (Asane-Otoo 2015). There is a two-step procedure to follow while applying DK approach. First, the mean factors from the independent variables and residuals are computed, and secondly, the computed averaged estimates are further used in weighted heteroskedasticity and autocorrelation steady estimator to produce common errors that own other quality in contrast to cross-sectional dependence (Baloch, Danish, and Meng 2019; Gnangnon 2020; Özokcu and Özdemir 2017). While the traditional fixed effect approach overlooks the presence of cross-sectional dependence even when grouping the standard errors, DK estimation produces "standard errors that are resistant to general types of cross-sectional and temporal dependency" (Jochmans and Verardi 2020).

3.3.2. Robustness Check

The two-step system Generalized Method of Moments (System-GMM) was adopted to help validate results from the CCEMG, AMG, and DK estimators, respectively. System-GMM estimates the time and country-specific effects simultaneously. Thus, to curb endogeneitythe system-GMM solves endogenous problems (Appiah, Li, and Frowne 2020). The system-GMM estimator uses a dual-diagnostic assessment. First, the Hansen J-statistic test ascertains the instruments' validity to verify any correlation with the residual. Secondly, the Arellano-Bond test, checks for second-order autocorrelation. The model for the system-GMM estimations per the study variables is thus specified as:

$$lnICG_i = \alpha_0 + \alpha_1 lnICG_{it-1} + \alpha_2 lnCO_{2it} + \alpha_3 lnREN_{it} + \alpha_4 lnFD_{it} + \alpha_5 lnFDI_{it} + \alpha_6 lnGCF_{it} + \mu_{it} \tag{10}$$

4. Empirical Results

The empirical outcomes of the various tests are presented with economic implications. These include summary statistics, various intermediary tests, and econometric tests.

4.1. Summary Statistics

The variables' summary statistics include inclusive growth, financial development, carbon emission, renewable energy, gross capital formation, and foreign direct investment for the study, displayed in Appendix C. The summary statistics are categorized into the aggregate group (all the countries under the study), LIC, and MIC sub-groups. Among all the means concerning the variable averages for the aggregate panel, the GCF recorded the highest mean of 21.482 with a standard deviation of 1.699 (maximum = 25.302, Minimum = 15.758). CO_2 recorded the lowest mean of −0.953 with a standard deviation of 1.479 (maximum = 2.302, Minimum = −4.118). Kurtosis for the aggregate group is reported as platykurtic for ICG, $CO_{2,}$ and GCF are, while FND, REN, and FDI show leptokurtic kurtosis. Skewness shows that ICG, FND, and CO2 are positively skewed, while REN, FDI, and GCF are negatively skewed. Kurtosis for LIC and MIC sub-groups displays ICG, $CO_{2,}$ and GCF are platykurtic kurtosis. Skewness both sub-groups displays the same behavior, ICG, FND, and CO_2 are all positively skewed while REN, FDI, and GCF are negatively skewed. To further find out if the data for the study is normally distributed or not the Shapiro-Wilk Normality Test is executed. From the results, the null hypothesis that the variables for the study are normally distributed was rejected; thus, the study used the non-parametric tests in the distributive non-parametric estimation procedure. For the correlations, the coefficients among the explanatory variables across all the panels are within the suitable values of confirming the nonexistence of multicollinearity. The rule of thumb is that to ensure the absence of multicollinearity, the correlation coefficient must be less than 0.8 (Gujarati and Porter 2009; Maji 2019; Musah et al. 2020).

4.2. Multicollinearity test

As outlined in Appendix D, the VIF statistics are far below 10, with their corresponding tolerance estimates above 0.2 for all series of variables among the country classifications employed. This, therefore, indicates that explanatory variables are not highly correlated; hence, multicollinearity issues are not much of a concern in the analysis (Mensah et al. 2019).

4.3. Cross-sectional dependence and Slope Homogeneity tests

The Pesaran Scaled LM, Breusch-Pagan LM, and Pesaran-CD tests are presented in Table 1. Evidently, the null hypothesis of no cross-sectional dependence in variables was rejected at 1% level of significance for all test statistics considering the various country groupings. There is strong evidence to conclude that the panel data pertaining to this extant study exhibits residual cross-sectional reliance issues across all panels. Considering the Pesaran and Yamagata (2008) homogeneity test, Table 1 further shows that the null conjuncture of slope homogeneity is rejected across all panels. This is confirmed by the delta-tilde and adjusted delta-tilde statistics with tire respective probability values for all observed series of variables in the various country groupings. With strong evidence, we can conclude that there is slope heterogeneity within the model for all three groups (Mensah et al. 2019). The confirmation of the issues concerning residual cross-sectional connectedness and slope heterogeneity will therefore select appropriate and efficient econometric methods.

4.4. Panel Unit root tests

Due to the existence of residual dependencies within the cross-section, the study conducted the CADF and the CIPS unit root tests, which are resilient to CD; the test is to ascertain the integration order of the variables. From the results depicted in Table 2, all the variables are witness to be non-stationary at levels [I(0)]; however, they became stationary after converting them into the first difference [I(1)].

Table 1. Cross-Sectional Dependency Test and Pesaran-Yamagata Slope Homogeneity Test.

	Aggregate		LIC		MIC	
Test type	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
CD Test						
Breusch-Pagan LM	5977.871[a]	0.000	674.6022[a]	0.000	1452.007[a]	0.000
Pesaran scaled LM	102.108[a]	0.000	22.67027[a]	0.000	41.55484[a]	0.000
Pesaran CD	45.515[a]	0.000	10.62167[a]	0.005	15.56425[a]	0.000
Slope Homogeneity Test						
Delta tilde ($\tilde{\delta}$)	1501[a]	0.000	349.7[a]	0.003	493.2[a]	0.000
Adjusted Delta tilde ($\tilde{\delta}_{adj}$)	7.437[a]	0.000	4.408[a]	0.006	5.96[a]	0.000

Source: *Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm*

Table 2. Panel Unit Root Test.

		CADF				CIPS			
		Levels		First Difference		Levels		First Difference	
Group		Value	Decision	Value	Decision	Value	Decision	Value	Decision
Aggregate	ICG	−1.204	I(0)	−3.210[a]	I(1)	−1.804	I(0)	−3.500[a]	I(1)
	CO_2	−1.910	I(0)	−2.884[a]	I(1)	−2.073	I(0)	−4.247[a]	I(1)
	REN	−1.969	I(0)	−2.845[a]	I(1)	−1.914	I(0)	−3.865[a]	I(1)
	FND	−1.687	I(0)	−2.330[a]	I(1)	−2.091	I(0)	−4.551[a]	I(1)
	FDI	−2.038	I(0)	−3.390[a]	I(1)	−1.281	I(0)	−3.273[a]	I(1)
	GCF	−1.532	I(0)	−3.194[a]	I(1)	−2.099	I(0)	−4.267[a]	I(1)
LIC	ICG	−1.935	I(0)	−2.870[a]	I(1)	−2.057	I(0)	−3.982[a]	I(1)
	CO_2	−1.288	I(0)	−2.807[a]	I(1)	−1.525	I(0)	−4.083[a]	I(1)
	REN	−2.003	I(0)	−2.704[a]	I(1)	−2.014	I(0)	−3.963[a]	I(1)
	FND	−1.786	I(0)	−2.283[a]	I(1)	−1.523	I(0)	−3.469[a]	I(1)
	FDI	−1.144	I(0)	−2.451[a]	I(1)	−1.395	I(0)	−3.217[a]	I(1)
	GCF	−1.674	I(0)	−3.389	I(1)	−1.366	I(0)	−3.492[a]	I(1)
MIC	ICG	−1.985	I(0)	−3.098[a]	I(1)	−1.558	I(0)	−3.444[a]	I(1)
	CO_2	−1.799	I(0)	−2.665[a]	I(1)	−1.359	I(0)	−3.261[a]	I(1)
	REN	−1.979	I(0)	−2.917[a]	I(1)	−1.923	I(0)	−3.938[a]	I(1)
	FND	−1.732	I(0)	−2.311[a]	I(1)	−1.611	I(0)	−3.687[a]	I(1)
	FDI	−1.839	I(0)	−2.492[a]	I(1)	−1.177	I(0)	−3.266[a]	I(1)
	GCF	−1.862	I(0)	−2.001[c]	I(1)	−1.211	I(0)	−2.933[a]	I(1)

Source*: Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm*

4.5. Panel cointegration tests

Considering the decision made on the series of variables as I(1), the study conducted the Westerlund (2007) cointegration test for the aggregate group and LIC and MIC sub-groups. From the outcome in Appendix E, except for G_t (between groups), all the other tests displayed the null hypothesis of no cointegration was rejected. Therefore, the results generally confirm a long-run relationship amid the variables for all the three-county group classifications.

4.6. Panel model estimation

After confirming cointegration in the long run, the elasticities of ICG with respect to FND, CO_2, and REN together with FDI and FND as control variables were estimated through the CCEMG, AMG, and DK estimators. Notably, the DK estimator serves as a benchmark for the aggregated panel together with the sub-panels. From Table 3, the results clearly display that, with all factors held constant, FND is positive and significant to inclusive growth for the aggregate group. Specifically, *ceteris paribus* a 1% increase in FND will cause a corresponding increase between 0.174% and 0.172% in inclusive growth. Again, all things being equal, a positive and statistically significant effect is evidenced from CO_2 is to ICG for the aggregate group. Thus, a 1% increase in CO2 emission will increase between 0.113% and 0.118% in ICG. However, renewable energy recorded a negative and insignificant impact on inclusive growth. From this statistical viewpoint, a percentage increase in REN all things been equal will cause a decrease of 0.268% and 0.261% in ICG. Summarily, FND, CO_2, and REN show an elastic relationship with ICG.

In the case of the LIC and MIC sub-groups, outlined outcomes from Tables 4 **and** 5, unveils that FND all things been equal is significant and positively related to inclusive growth. The LIC sub-group elasticity estimation revealed that, 1% increase in FND will result in an increase of 0.158% and 0.156% in ICG. In the MIC sub-group *ceteris paribus* 1% increase in FDV will correspond to an increase of 0.256% and 0.254% in ICG. Therefore, FND has higher impact on inclusive growth in MIC sub-group than in LIC sub-group. In addition, with all factors held constant for LIC, 1% increase in CO_2 would cause 0.083% and 0.082% increase in ICG. Likewise, for the MIC sub-group, 1% increase in CO_2 will

Table 3. Aggregate Group (All countries) estimation outcomes.

	CCEMG		AMG		DK	
	coef	prob	coef	prob	coef	prob
CO_2	0.113[c]	0.099	0.118[b]	0.039	0.106[a]	0.000
	(0.068)		(0.052)		(0.006)	
REN	−0.268	0.236	−0.261	0.305	−0.251	0.139
	(0.352)		(0.355)		(0.015)	
FND	0.174[c]	0.072	0.172[c]	0.084	0.163[a]	0.001
	(0.412)		(0.470)		(0.317)	
FDI	−0.015	0.153	−0.013	0.296	−0.025	0.124
	(0.011)		(0.010)		(0.010)	
GCF	0.083[a]	0.001	0.084[a]	0.000	0.078[a]	0.000
	(0.025)		(0.021)		(0.010)	
Constant	4.570	0.740	8.656[a]	0.000	9.014[a]	0.000
	(7.752)		(1.158)		(0.108)	
R-squared	-		-		0.836	
Probability	-		-		0.000	
Wald chi2(5)	19.23		22.25		-	
Prob > chi2	0.0017		0.000		-	
Observations	912		912		912	
No of Groups	48		48		48	
RMSE (sigma)	0.0471		0.0674		-	

Source: *Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm. Figures in parenthesis are the standard error.*

Table 4. LIC (Low-Income Countries) estimation outcomes.

	CCEMG		AMG		DK	
	coef	prob	coef	prob	coef	prob
CO_2	0.083[c]	0.071	0.082[c]	0.079	0.078[a]	0.000
	(0.079)		(0.081)		(0.092)	
REN	−0.007[b]	0.036	−0.005[b]	0.032	−0.004[c]	0.069
	(0.479)		(0.480)		(0.601)	
FDI	−0.002	0.832	−0.002	0.852	−0.017	0.639
	(0.009)		(0.009)		(0.008)	
FND	0.158[c]	0.089	0.156[c]	0.061	0.162[a]	0.000
	(0.592)		(0.529)		(0.437)	
GCF	0.070[a]	0.003	0.076[a]	0.009	0.081[b]	0.058
	(0.024)		(0.024)		(0.015)	
Constant	6.829[a]	0.005	6.901[a]	0.000	9.809[a]	0.000
	(1.963)		(1.968)		(0.617)	
R-squared	-		-		0.681	
Probability	-		-		0.000	
Wald chi2(5)	15.95		17.73		-	
Prob > chi2	0.007		0.085		-	
Observations	399		399		399	
No of Groups	21		21		21	
RMSE (sigma)	0.0201		0.0348		-	

Source: *Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm. Figures in parenthesis are the standard error.*

result in an increase of 0.136% and 0.130% in ICG. On significance, CO_2 is only significant to inclusive growth for the LIC sub-group but not to MIC sub-group. According to the elasticity outcomes in LIC, all factors remaining the same, as 1% increase in REN will significantly cause a decrease of 0.007% and 0.005% in ICG. For the MIC sub-group, the elastic coefficients show that 1% increase in REN will

Table 5. MIC (Middle-Income Countries) estimation outcomes.

	CCEMG		AMG		DK	
	coef	prob	coef	prob	coef	prob
CO_2	0.136 (0.087)	0.118	0.130 (0.083)	0.118	0.108 (0.012)	0.131
REN	−0.167 (0.191)	0.281	−0.168 (0.195)	0.292	−0.163 (0.183)	0.137
FDI	−0.015[c] (0.009)	0.083	−0.015[c] (0.009)	0.081	−0.017[c] (0.011)	0.084
FND	0.256[c] (0.570)	0.071	0.254[c] (0.575)	0.069	0.247[c] (0.544)	0.053
GCF	0.082[b] (0.013)	0.013	0.082[a] (0.018)	0.000	0.084[c] (0.015)	0.083
Constant	0.414[a] (1.588)	0.002	0.541[a] (1.542)	0.000	1.317[a] (0.170)	0.000
R-squared	-		-		0.696	
Probability	-		-		0.000	
Wald chi2(5)	9.55		12.43		-	
Prob > chi2	0.009		0.000		-	
Observations	513		513		513	
No of Groups	27		27		27	
RMSE (sigma)	0.0404		0.0514		-	

Source: *Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm. Figures in parenthesis are the standard error.*

result in a decrease of 0.167% and 0.168% in ICG. Based on the significant contribution, Renewable energy has an insignificant impact on inclusive growth in the case of MIC sub-group. Similarities in the results of the estimators imply the results are robust.

The DK regression results show that, for the model adopted, the R-Squared for the aggregate group is 0.836 and that for the LIC and MIC sub-groups are 0.681 and 0.696, respectively. This shows that the relative measure of fit for the independent variables to the output value fits the study's model well. For the CCMG and AMG regressions, the RMSE (Root Mean Squared Error) sigma for all the groups is below 0.1 means that an absolute measure of fit for the model is good.

4.6.1. Robustness Results

It is imperative that this extant study investigates the robustness of the AMG together with the CCEMG and DK estimators via the system GMM approach. Table 6 displays the estimates from the system-GMM technique among the employed study panels. According to the estimates, the variables exhibit inelastic relationship with inclusive growth. Inclusive growth gained in the previous year is substantial and positive to inclusive growth in the current year in the short run. *Ceteris paribus*, a percentage change in CO_2 will cause an increase of 0.077% in inclusive growth in the short-run at 5% significance level on average for all countries, also, 0.093% and 0.139% in LIC and MIC, respectively. Again, all factors held constant, a percentage change REN will correspond with a decrease of 0.202% in inclusive growth for all countries, 0.008% and 0.162% decrease in LIC and MIC, respectively. For FND, all things being equal, a percentage change in it, is associated with a 0.168% increase in inclusive growth in the short-run at 5% significance level on average in all countries, also 0.154% and 0.027% increase in LIC and MIC. Concerning the control variables, FDI and gross capital formation show the mixed significance and insignificant impacts toward inclusive growth. Summarily we can infer that, given the variations among the estimates from one estimator to the other, the respective overall effects on inclusive growth in each panel regarding the system GMM estimation approach are consistent with those of the outcomes from the AMG together with the CCEMG and DK methods.

Table 6. System-GMM estimations.

Variable	All Countries	LIC	MIC
L.ICG	0.8720[a]	0.9393[a]	0.7601[a]
	(0.0170)	(0.0801)	(0.0170)
CO_2	0.0977[b]	0.0935[c]	0.1391
	(0.0113)	(0.0209)	(0.1125)
REN	−0.2029	−0.0087	−0.1624
	(0.0091)	(0.1108)	(0.1125)
FND	0.1685[b]	0.1541[a]	0.0275[b]
	(0.0283)	(0.0634)	(0.2583)
FDI	−0.0183	0.0019	−0.0195[c]
	(0.0046)	(0.0037)	(0.0083)
GCF	0.0865[b]	0.0736[b]	0.0852[c]
	(0.0138)	(0.0091)	(0.0226)
No. of instruments	24	17	23
No. of countries	48	21	27
Observations	864	378	486
Year Dummy	Yes	Yes	Yes
F-Statistics	2119.73[a]	1271.34[a]	1635.05[a]
AR(2) P-value	0.254	0.336	0.235
Hansen test	21.92	19.58	14.92
Hansen P-value	0.188	0.297	0.384

Source: *Authors' calculations. The superscript 'a,' 'b', and 'c' denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm. Figures in parenthesis are the standard error. L.ICG is the lag of ICG.*

5. Discussion

Generally, carbon emission is vital to inclusive growth in Africa as a whole. The finding supports the carbon-growth nexus, thus the EKC theory where carbon emission and growth positively correlate up to a threshold; currently, Africa is on the rise; therefore, a positive correlation between inclusive growth and carbon emission is realized. This outcome can be attributed to Africa's carbon emissions are primarily from industries and transportation; thus, fuel usage (Asane-Otoo 2015). The outcome supports the studies of Mardani et al. (2019), who trumpeted that most studies on carbon emission and growth show a positive relationship, but after a certain threshold, it shows a negative correlation. As industries and manufacturing increase, so is carbon emission; these industries are job creation avenues that means more jobs are created due to the increase in carbon-related activities. Africa's carbon emission and inclusive growth relationship slightly differ when analyzing it from countries' income levels. Carbon emission are significant to inclusive growth in low-income countries but not in middle-income countries. In the low-income countries, carbon emission is vital to inclusive growth because more industries are critical for the growth of the economies, regardless of the environmental regulations. As a result, most industries will disregard the regulations, and the governments will turn a blind eye to it since the industries are critical to the economy.

Besides, the low-income countries allow old models of cars that emit more carbon to be imported into the countries. However, in middle-income countries, industries are made to adhere to environmental regulations in their operations. Though the industries are needed, there is also the need to regulate the activities to be environmentally friendly. The type of vehicles imported into the middle-income countries is appropriately regulated, which means more eco-friendly vehicles are allowed. Unlike low-income countries, middle-income countries are also not manufacturing industrial dependent but gradually shifting to the service sector. This outcome may be relevant in the short term as in the future, with the influx of electric vehicles and carbon-reduction activities. Africa may emulate the initiative by Greece to do away with carbon-emitting industries and transportations, Marinakis et al. (2020) explained the energy efficiency first initiative whereby 2028 all lignite facilities will be decommissioned and intensify sustainable energy usage to contribute toward the Megalopolis' energy transition.

Furthermore, on inclusive growth and renewable energy, the study signifies that renewable energy has a negative impact on inclusive growth in Africa as a whole. This result is in line with Nikas et al. (2020), who opined that renewable energy significantly drives low-carbon transition, affecting the economic recession, leading to severe economic and social consequences. The result supports the energy economic growth theory, because low energy conception in Africa, has led to low renewable energy compared to the needed energy in Africa. However, in the study of Neofytou et al. (2020), it was revealed that energy efficiency and renewable energy supports macroeconomic indicators but not necessarily the economy in general. The study can attribute the negative relationship to the assertion that energy consumption is relatively low (compared with the needed capacity) in Africa, as the Renewable Energy Policy Network report for the 21st Century (REN21) states.

Energy consumption in Africa is generally lower than in other parts of the world (Müller et al. 2020). Since the entire energy consumption is low, it makes the consumption of renewable energy relatively low, that is to say renewable energy consumption is a portion of the entire energy consumption. Considering the income levels of countries in Africa, renewable energy is negatively significant to inclusive growth in low-income countries; this finding supports the assertion of El-Karimi and EI Ghini (2020), but it is not significant to middle-income countries. This is because, in low-income countries, renewable energy consumption has not essentially generated jobs. In low-income countries renewable energy consumption is low because energy generation is a problem, the countries have an energy deficit, therefore, they are not able to generate enough renewable energy to stimulate job creation and growth in general. However, middle-income countries are gradually embracing renewable energy sources like solar and wind; therefore, policies are being put in place to sustain jobs while focusing on generating extra renewable energy. For renewable energy to have a significant and positive impact on inclusive growth in Africa, policymakers must consciously attract more investment into the renewable energy sector. Then, it will begin to have a positive impact on job creation and, by extension, inclusive growth.

Financial development in the aggregate and the sub-groups reported a homogeneously positive and significant relationship with inclusive growth. Al-mulali and Che Sab (2018) and Asumadu-Sarkodie and Owusu (2017) also shared this point, who attained similar outcomes in their studies. Therefore, the study supports the finance-led growth theory, where finance determines how growth is experienced; thus, a resilient financial background will lead to growth at all times. This finding happens to be critical to Africa because if the financial sector is expanded, and there is a fair opportunity for all to embrace financial participation and liberty, then more jobs will be available for Africans; by this opinion, the study agrees with the suggestion of Ntow-Gyamfi et al. (2019). The majority of people employed in Africa are engaged by smaller businesses that are privately owned.

In effect, regardless of a country's income level, financial development is critical to enhancing inclusive growth. Financial development has a higher impact in middle-income countries than in low-income countries, and this can be attributed to the robust financial-sector arrangements put in place by middle-income countries. The study buttresses the point made by Swamy (2010) that, as part of policy implementation, it is advised that, policymakers in the quest to reduce poverty and increase wealth creation, the financial sector needs much push to catalyze inclusive growth. The study suggests that generally, if smaller businesses are supported by implementing favorable financial policies, it will generate employment across the continent, reducing poverty and raising the standard of living in Africa.

Additionally, the study used foreign direct investment and gross capital formation as control variables for the estimations. The variables respond to long-run equilibrium deviations where foreign direct investment negatively impacts inclusive growth; this supports Sokhanvar (2019), and Alvarado, Iñiguez, and Ponce (2017), who studied foreign direct investment and economic growth and discovered a similar finding in their studies. Gross capital formation positively influences inclusive growth; this finding aligns with Raheem, Isah, and Adedeji (2018) and Ntow-Gyamfi et al. (2019), who agree that capital and improvement in fixed assets leads to inclusive growth.

6. Conclusion

The study focused on the impact of carbon emission, renewable energy, and financial development on inclusive growth in Africa. The study adopted three distinctive methodologies to ascertain the impact and influence of the variables of interest on inclusive growth, namely; CCEMG, AMG, DK, and system-GMM as robustness check. The data is from 48 African countries grouped into LIC and MIC. The findings indicated that carbon emissions have a beneficial effect and are also critical for inclusive growth in Africa. Carbon emissions from industries and transportation are cited as reasons for this. Industrialization is critical to Africa's progress as industries provide employment and increase growth. Carbon emissions, on the other hand, contribute significantly to inclusive development in low-income countries but not in middle-income nations; as a result of the implementation of environmental rules, low-income countries seem to loosen these restrictions in order to build their economies. Africa is widely known to be a low generator of carbon footprint; therefore, policy on climate change and carbon emission in Africa must not be implemented as a blanket policy but rather, the country's income level must be considered. In any future climate policy deal, African countries will almost certainly avoid strict carbon obligations. This may have an impact on the efficacy of global accords, as shown with the Kyoto Protocol.

Another scientific finding from this research is that renewable energy has a detrimental effect on Africa's inclusive growth. The result may be attributed to Africa's low energy consumption (which renewable energy is a portion of it), with the majority of nations struggling with the energy deficit. Renewable energy has a negative impact on inclusive growth in Africa as a whole as well as in both low-income and middle-income country groupings. The policy on renewable energy in Africa stipulates that by 2030, an additional 300 GW of renewable energy will be added to the renewable energy production in Africa, dubbed; The African Renewable Energy Initiative (Müller et al. 2020). Attaining such initiative may not be a priority for low-income countries in Africa since it has not proved to generate jobs rapidly.

Finally, the study revealed that Svirydzenka's (2016) financial development has a positive effect on and is also critical for inclusive growth; an improvement in Africa's financial sector will increase the equitable opportunity for all to embrace financial participation and liberty, which will result in increased job opportunities. Regardless of the methodology used, low- and middle-income nations respond similarly to the research. This finding is consistent with the finance-led growth paradigm. This shows that it is a general phenomenon that inclusive growth will be boosted if financial access and participation are encouraged in Africa. The policy on financial development in Africa, the African Union, through the African Development Bank, should consider implementing policies that directly impact job creation and support small and medium enterprises since those will ensure job security and improve inclusive growth.

On policy recommendations, the study recommends to the African union to tackle carbon emission and renewable energy on the basis of the countries income levels. In low-income countries, various governments must put together attractive investment packages for industries who take practical steps to reduce carbon emission. For middle-income countries, the study recommends stricter measure are put in place to ensure industries adhere to international agreement on carbon emission like Kyoto protocol, and the United Nations Framework Convention on Climate Change. On renewable energy, the study recommends that both low and middle – income countries should stick to the African Renewable Energy Initiative. In addition, the African Development Bank's financial framework must be centered on job creation.

The limitations of this study are; the study did not consider individual countries, again sub-regional blocs were not considered, therefore, the study may not necessarily reflect the reality in individual countries as well as sub-regional blocs, which may show different outcomes. The study also recommends that further studies may be conducted into how carbon emission, renewable energy has impact on inclusive growth in specific African countries as well as sub-regional blocks; North, East, West, Central, and Southern Africa.

Highlights

- Carbon emission supports inclusive growth in Africa as a whole.
- Renewable energy significantly reduces inclusive growth in low-income countries.
- Financial development significantly improves inclusive growth in Africa as a whole and middle-income countries.
- Middle-income countries do not significantly benefit from carbon emission.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conceptualization, and formal analysis and investigation was done by Easmond Baah Nketia; Methodology was performed by Kingsley Anfom. The original draft was prepared by Sabina Ampon-Wireko. Resources and software codes were provided by Isaac Adjei Mensah. The funding acquisition and Supervision was by Yusheng Kong. All authors were involved in the review and editing process. All authors read and approved the final manuscript.

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APPENDICES

Appendix A

African countries included in the studies.

Group	Countries
Aggregate (All countries)	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Congo Republic, Cote d'Ivoire, Egypt, Equatorial Guinea, Eswatini, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe
LIC (Low- Income Countries)	Benin, Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of Congo, Ethiopia, The Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Tanzania, Togo, Uganda
MIC (Middle- Income Countries)	Algeria, Angola, Botswana, Cabo Verde, Cameroon, Comoros, Congo Republic, Cote d'Ivoire, Egypt, Equatorial Guinea, Eswatini, Gabon, Ghana, Kenya, Lesotho, Libya, Mauritania, Mauritius, Morocco, Namibia, Nigeria, Senegal, South Africa, Sudan, Tunisia, Zambia, Zimbabwe

Appendix B

Variable description and data sources.

variable	Description	Measurement	Source
ICG	Inclusive growth indicator	Natural log of GDP per person employed (constant 2017 PPP $)	World Development Indicators 2020
CO_2	Carbon emission	Natural log of CO2 emissions (metric tons per capita)	World Development Indicators 2020
REN	Renewable energy consumption	Natural log of percentage of total final energy consumption (billions of kilowatt hours)	World Development Indicators 2020
FND	Financial Development Index	Natural log of Computed financial debt, financial access, and financial institutions of various countries	International Monetary Fund 2020
FDI	Foreign Direct Investment	Natural log of Foreign direct investment, net inflows (% of GDP)	World Development Indicators 2020
GCF	Capital	Natural log of Gross capital formation (% of GDP)	World Development Indicators 2020

Source: *Authors' compilation*

Appendix C

Summary statistics, correlation matrix, and normality test.

Group		ICG	FND	CO_2	REN	FDI	GCF
Aggregate	Mean	9.112	0.144	−0.953	3.802	19.211	21.482
	Maximum	11.683	0.648	2.302	8.765	23.172	25.302
	Minimum	7.223	0.028	−4.118	−2.831	9.345	15.758
	Std. Dev.	1.055	0.101	1.479	1.162	2.111	1.699
	Skewness	0.357	2.306	0.312	−2.673	−0.995	−0.01
	Kurtosis	2.107	8.848	2.298	12.623	4.635	2.749
	ICG	1.000					
	FND	0.504	1.000				
	CO_2	0.710	0.600	1.000			
	REN	−0.641	−0.355	−0.668	1.000		
	FDI	−0.348	−0.368	−0.369	−0.239	1.000	
	GCF	0.452	0.471	0.451	−0.383	0.797	1.000
	SW Test	7.800	12.432	6.684	13.055	8.316	3.481
LIC	Mean	8.169	0.098	−2.234	4.398	18.491	20.705
	Maximum	9.025	0.209	−0.487	4.588	22.625	24.171
	Minimum	7.223	0.028	−4.118	3.874	9.345	15.758
	Std. Dev.	0.423	0.029	0.722	0.153	2.180	1.455
	Skewness	0.106	0.394	0.008	−1.532	−1.052	−0.236
	Kurtosis	2.088	3.484	2.791	4.924	4.586	2.839
	ICG	1.000					
	FND	0.083	1.000				
	CO_2	0.596	0.382	1.000			
	REN	−0.559	−0.205	−0.558	1.000		
	FDI	−0.122	−0.204	−0.153	−0.176	1.000	
	GCF	0.072	0.248	0.037	0.163	0.731	1.000
	SW Test	4.574	3.079	2.748	9.023	6.596	2.275
MIC	Mean	9.846	0.180	0.043	3.339	19.770	22.087
	Maximum	11.683	0.648	2.302	8.765	23.172	25.302
	Minimum	6.423	0.033	−1.869	−2.831	11.447	17.962
	Std. Dev.	0.780	0.120	1.101	1.376	1.875	1.629
	Skewness	0.111	1.595	0.279	−1.891	−0.909	−0.082
	Kurtosis	2.273	5.299	2.163	8.157	4.366	2.525
	ICG	1.000					
	FND	0.359	1.000				
	CO_2	0.726	0.531	1.000			
	REN	−0.552	−0.210	−0.618	1.000		
	FDI	−0.240	−0.368	−0.283	−0.192	1.000	
	GCF	0.307	0.435	0.339	−0.327	0.720	1.000
	SW Test	6.135	9.895	6.116	10.368	6.563	3.699

Source: *Authors' calculations. Variables are in natural logarithm. SW test is the Shapiro-Wilk Normality Test figures shown are the z test results.*

Appendix D

Multicollinearity Test.

	Aggregate		LIC		MIC	
Variable	VIF	Tolerance	VIF	Tolerance	VIF	Tolerance
ICG	-	-	-	-	-	-
GCF	3.260	0.307	2.360	0.424	3.570	0.280
FDI	2.820	0.355	2.270	0.440	3.160	0.317
CO_2	2.540	0.393	1.780	0.563	2.250	0.444
REN	1.910	0.524	1.620	0.617	1.820	0.548
FND	1.720	0.580	1.260	0.796	1.650	0.606

Source: *Authors' calculations. Variables are transformed into natural logarithm.*

Appendix E

Westerlund Panel Cointegration test.

	Aggregate		LIC		MIC	
Statistic	Value	Robust P-value	Value	Robust P-value	Value	Robust P-value
Gt	−2.938	0.305	−3.281	0.175	−3.733	0.130
Ga	−5.058[c]	0.055	−5.810[a]	0.005	−6.065[a]	0.005
Pt	−35.371[a]	0.005	−13.989[c]	0.080	−17.003[c]	0.065
Pa	−10.011[a]	0.000	−7.809[a]	0.010	−7.170[a]	0.000

Source*: Authors' calculations. The superscript "a," "b," and "c" denotes significance at 1% 5% and 10% respectively. Variables are transformed into natural logarithm.*