# Does Agricultural development induce environmental pollution in E7? A myth or reality

## Abstract

Environmental degradation caused by various human activities has been a subject of attention over the globe. There is a concern on how to maintain a clean environment and at the same time achieve optimum production of food and non-food products amidst global energy demand. To this end, this study examines the impact of agricultural development, energy use and economic growth on $CO_2$ emissions in the emerging seven countries that comprises China, India, Brazil, Mexico, Russia, Indonesia and Turkey for the annual time frequency from 1990 to 2016. The study uses a battery of econometrics techniques for soundness of analysis the consist of Pooled MeanGroup-Autoregressive Distributed Lag methodology, Dynamic Ordinary Least Squares and Fully Modified Ordinary Least Squares as estimation techniques alongside Dumitrescu and Hurlin Causality Test for the direction of causality analysis. Empirical results revealed that Agricultural value-added and economic growth are drivers of $CO_2$ emission in the E7 countries while the rise in renewable energy causes a reduction in $CO_2$ emissions. While in the short-run, economic growth has a positive impact on emissions in the focus countries. While causality analysis shows that there is a feedback causality between economic growth and emissions, agriculture value-added and energy usage, emission and agriculture value-added as well as economic growth and agricultural development. Furthermore, energy use does not cause emissions directly, it causes economic growth and agriculture value-added which causes emissions. This position aligns with the advocacy of the United Nations Sustainable development goals (UN-SDGs) targets 7 and 13 of clean energy access and mitigation of climate changes issues.

**Keywords**: Agricultural development; Energy Consumption; Economic growth; $CO_2$ emissions; E7 countries

## 1. Introduction

The Food and Agricultural Organization (2017) report states that for many developing, transition and emerging economies, the key characteristics of global population growth, declining fertility rates, increasing standard of living and protracted ageing levels demonstrate that a substantial rise for inhabitants is expected to occur in anticipation of around the end of the 21st century. Over one-third of the world, inhabitants are subsistence focused on agriculture, and most are in Asia[1]. Consequently, the agriculture field remains dominant in all territories and plays a significant function throughout the sectors for development, notably in underdeveloped countries. Nonetheless, some areas, such as soil pollution, habitat destruction, resource scarcity and habitat destruction, hold out as environmental and economic challenges and appeal for further infrastructure in agriculture sustainability (Balsalobre-Lorente et al., 2019).

Reynolds and Wenzlau (2012) and Sinha and Sengupta (2019) established that approximating supplementary industries which proofs that, cultivation needs power as a critical contribution to development. In particular, the agriculture industry utilizes non-renewable power bases, such as fossil fuels, coal, fume and oil and coke, for the operation of industrial machinery, for heating or cooling structures and for providing lighting systems on the farm, and unintentionally for fertilizers, equipment and pesticides manufactured out of the farm. As a result of its heavy use of fossil fuels, the ratio of the agriculture sector to global pollutant (GHG) production is roughly 14–30 per cent (Balsalobre-Lorente et al., 2019).

---

[1] Food and Agriculture Organization of the United Nations (FAO) 2017

Given the environmental implications and increasing questions about the ability of the agriculture sector to decrease GHG pollution, the usage of clean energy power has appeared as an essential aspect of global energy use. According to FAO (2016), 20% of GHG contributions from anaerobic decomposition in livestock, rice development in submerged areas through the use of NPK fertilizers in addition to waste are produced by cultivation, forestry in addition to the cultivation of land reform, contributing to anthropogenic greenhouse reform and greenhouse gases.

Best (1998) declared that attention in the development of agriculture ought to be driven by homegrown cultural, ecological and communal requirements. Carbon strategy production will blend regional energy production strategies with geographically considered preferences. Focus ought to be put on non-fossil petroleum replacements for providing energy infrastructure in cultivation in emerging nations. Renewable energy techniques should be implemented in countless places around the realm for numerous farming implementations to mitigate greenhouse gas ($CO_2$) consumption from fossil fuels, minimize energy market uncertainty impact on the environment, and thereby improve economic development (Tiwari 2011; Shafiei & Salim 2014, Shahbaz et al. 2020).

Through the use of clean sources of energy, advancement in addition to enhancement of productivity potential in farming is of vital significance intended for sustainability development in emerging countries. The PWC study (2017) estimated that the global economy continues to expand at an estimated annual premier league experience of about 2.5 per cent annually within 2016 and 2050. The trend, combining with a rise in energy consumption, will be fueled primarily by emerging nations such as the Emerging 7 nations commonly known as the E7 nations which are made up of Brazil, China, India, Indonesia, Mexico, Turkey and Russia– rising next to an estimated yearly pace of about percentage of 3.5 during the subsequent 34 years, opposed to just approximately 1.6 per cent for developed G-7 nations. Bloomberg's Novel power Finance Account (2016) also reported that emerging markets were for the first opportunities ahead of advanced nations within 2015 in expressions of actual fresh investments in clean power sources.

Capital expenditure in clean energy in Brazil, India as well as China, which are the biggest 3 nation within the E7, rose by 16 per cent of $120.2 billion in 2015, while other developed' nations experienced a 30 per cent boost in the direction of $36.1 billion (Aydoğan, & Vardar, 2020). The presence of an actual powerful clean power resource is identified as the core problem of economic development in farming as well as the extension of manufacturing of farm inputs for E7 states. Kaygusuz, Yuksek, &Sari (2007), Kaygusuz (2007), Zafar et al (2019), as well as Sinha et al (2017) argument, was based on the decision to encourage sustainable energy sources which will not only contribute to ever more restructuring of the power market, nonetheless but also help the fiscal performance in addition to corporate social responsibility goals of the various countries. Given the advent of renewable sources of energy in a potential discussion on clean energy in emerging countries, it is important to keep in mind the interactions regarding per capita $CO_2$ pollution and growth of the economy, agricultural value-added, and clean energy utilize across E7 countries over the timeframe 1990-2016 is the main motivation for this study

There have been good documented theoretical studies that investigate the relationship between environment-income-energy and economic growth literature for several regions and countries. However, there been no consensus on the empirical outcomes given the diverse econometrics modelling techniques, sample procedure, and much. There been vast theoretical studies such as (Soytas & Sari, 2009, Bekun et al.2019a, b). The intuition of the carbon-income function is premised on the environmental Kuznets Curve phenomenon that expresses the relationship between environmental degradation and income level. Our study advances the arguments by augmenting the conventional liner carbon-income model with agriculture as a key determinant of GHGs for the case of E7.To this end, based on the literature trajectory the current study complements the extant literature by exploring the carbon-environment and economic growth nexus by augmenting the carbon-income function with the addition of energy consumption and agriculture as an additional determinant for pollutant emission for the case of E7 countries which has received less attention on the literature. This study employs robust and econometric analysis consistent with literature such as  Pool mean group autoregressive distributed lag (PMG-ARDL), dynamic ordinal least square (DOLS) and full modified ordinary least square (FMOLS)  for long –run regression among the outlined study variables while for detection of causality direction  Dumitrescu and Hurlin causality test is employed. Our study relies on first-generation panel analysis on the premise of the Pesaran (2015) cross-sectional dependency (CD) test that is a common shock effect among the blocs investigated for robustness purpose as well as avoid spurious analysis. The CD test result fails to support second-generation modelling, as such, we proceed with the first-generation panel estimator hereafter. The blocs investigated also share a common economic structure and characteristics, which makes valid the assumption of homogeneity in the panel investigated.  As outlined by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report that conventional energy consumption, economic expansion is a key driver of anthropogenic pollutant emissions (Etokakpan et al., 2020; Blanco et al., 2014). Thus, our study is motivated by the United Nations (UN) sustainable development goals (SDGs) and its influence by 2030, which addressed pertinent issues that concern human, and its activities. To this end, our study variables are informed by the above stated SDGs namely clean energy consumption (renewable energy consumption) (SDG-7), economic growth (SDG-8), responsible consumption (SDG-12) and climate change mitigation issues (SDG-13). These variables combinations align with existing literature and it is time to re-visit the theme for the case of E7 in an era of global energy awareness, energy security and a clean environment. This study seeks to further add to the existing literature ample policy guide and a prescription for the rest of other developing economies by serving as a benchmark

The rest of this paper is structured as follows: Section 2 provides a review of related literature. Section 3 focuses on the data and methodological procedure employed. While Section 4 concentrates on the interpretation of empirical findings. Finally, section 5 concludes the study with policy prescriptions accordingly.

## 2. Literature review

During the last two decades, large literature reviews have rigorously studied many of the variables that connect consumption of energy with growth as well as emissions of $CO_2$ (Agboola & Bekun,2019; Bekun et al.2019a; Bekun et al.2019b; Adedoyin et al., 2020b, 2020a; Kirikkaleli et al., 2020; Udi et al., 2020: Gyamfi et al, 2020a, Gyamfi et al. 2021b, c). These characteristics involve economic activity, energy efficiency, clean power and non-renewable power intake, import and export, travel, urbanization, fiscal advancement, FDI as well as tourism. Concerning the various geographical regions and states as well as the diverse period ranges and the diverse methodological methods, the association regarding $CO_2$ concentrations and the factors identified proposed a variety of suggestions and regulatory consequences for the survey states (*inter alia* Chebbi 2010; Chebbi et al. 2011; Iwata et al. 2011; Saboori et al. 2012; Farhani and Shahbaz 2014; Shahbaz et al. 2014; Apergis and Ozturk 2015; Ben Jebli and Ben Youssef 2015a, 2015b; Ben Jebli et al. 2015; Baek 2015; Bölük and Mert 2015; Ahmad et al. 2016; Bouznit and Pablo-Romero 2016; Lin et al. 2016; Saboori et al. 2016; Youssef et al 2016; Danish et al. 2017; Qureshi et al. 2017; Zhang et al. 2017)

Vogueish comparison towards the influence of all the considerations listed on $CO_2$ pollution, research on the effect of agricultural practices gained relatively minimal publication consideration from scholars, economic experts and authorities. Utilizing one-state (Karkacier et al. 2006; Mushtaq et al. 2007; Turkekul and Unakitan 2011; Sebri and Abid 2012) in addition to/otherwise boundary-nation documents established (Rafiq et al. 2016) popular modern research, in presence are research on the partnership involving power use besides agriculture. Research by Karkacier et al. (2006) explores how the effect of power usage scheduled the production of Turkish agriculture across the span of 1971 through to 2003. Quantitative findings confirm the presence of a close association regarding energy usage versus agricultural efficiency, which suggests that agricultural growth decreases with an improvement in energy intake. Which use a co-integration and error correction template, Mushtaq et al. (2007) have identified a Uni-directional cause and effect connection between agricultural GDP as well as oil consumption as well as power intake and agricultural GDP for Pakistan across the span 1972–2005. The findings have some strategy ramifications for policymakers and authorities in terms of upgrading facilities and subsidizing remote and industrial energy to increase agricultural production.

Turkekul and Unakitan (2011) measure the immediate and longstanding connection regarding power use, agricultural GDP in addition to oil values in Turkey throughout 1970 and 2008. Depending on the findings of the Granger causality study, oil costs have a major effect on electricity usage. Therefore, the presence of uni-directional connection since fuel plus electrical utilization to agricultural development implies the value of the power reliant on budget, which implies that any improvement in agricultural development would require a long-term improvement in fuel and electrical utilization. Energy usage in agriculture would also be promoted to increase the productivity of the international community. Sebri and Abid (2012) are researching the cause and effect connection involving energy use (petroleum and electric power) and agricultural value-added, regulating the opening up of trade in Tunisia within the span of 1980 to 2007. The findings of the connection analyses confirm the presence of a one-way causality starting efficiency power use and lubricant use to agricultural assessment supplementary in the temporary. The longstanding causal connection has identified a uni-directional cause and effect relationship between accessibility to trade and power use and agricultural value-added. Additionally, the findings confirm clear cause and effect since agricultural assessment supplementary to petroleum resource use in Tunisia.

Further notably, Rafiq, Salim in addition to Apergis (2016) examine the effect of agriculture as well as trading transparency on $CO_2$ consumption in a group of 53 large, low to medium-earnings states over the century, leveraging the generalized Stochastic Regression Effect, Contamination, Affluence and Innovation (STIRPAT) and EKC theory. Analytical findings show that the retail segment and agricultural added value have a major function to play in lowering emissions in large-income economies, while industrialization raises contamination rates. Both the capital investment in utilities and agriculture contribute to reducing pollution. The results set out the political ramifications of the integration of industrialization initiatives and green regulations to minimize $CO_2$ pollution from trade liberalization around the globe, regardless of the country's earnings rates.

In addition to exploring the EKC theory, our research reflects on the interaction involving clean power utilization, fiscal development, farming and pollutants. As stated before, while experiments are investigating the connection regarding farming and overall energy utilization in the documentation, the various examinations exploring the connection regarding renewable energy use, economic development, agriculture as well as $CO_2$ is very low. One small group of experiments is Ben Jebli and Ben Youssef (2017a) exploring the relation regarding $CO_2$ discharges, healthy, unclean power use, GDP, agricultural value-added as well as import and export transparency in Tunisia. Considering the Vector Error Correction Model (VECM) in addition to causal research, the methodological results confirm the presence of short as well as bi- effects on farming assessment supplementary in addition to $CO_2$ as well as on agricultural value-added and trade. While the definition of the EKC is not recognized in Tunisia during the 1980 to 2011 era, there is a lengthy-term bi-directional cause and effect over all of the variables described. In contrast, there is indeed a considerable improvement in the influence of non-renewable power, exports and agricultural added value on pollutants, while the influence of clean energy on $CO_2$ output is rising.

In the framework of a community of northern Africa states, Ben Jebli and Ben Youssef (2017b) investigate the energetic causal relationship regarding agricultural value-added, $CO_2$ pollution, green power usage and real GDP over the 1980 to 2011 span. Researchers contemplate the inclusion of a bi-directional causal association involving agriculture as well as $CO_2$ pollution both in the short and long term. Findings from long-term parameter projections show that an intensification in the use of clean power or GDP outcomes in an upsurge in $CO_2$ discharges, although an improvement in farming assessment supplementary has a declining effect on $CO_2$ greenhouse gases. According to earlier research, Liu et al. (2017) explored the influence of clean power usage and agricultural added value on $CO_2$ reductions in 4 designated ASEAN nations. They explore the occurrence of the EKC phenomena from 1970 to 2013 council of these nations. The findings never confirm the EKC theory. We also discover that renewable energies and agriculture have a major and detrimental effect on $CO_2$ production, while non-renewable generation does so favourably. This study varies from those of Ben Jebli and Ben Youssef (2017b) and Liu, Zhang and Bae (2017), primarily because we use a separate data collection, which included a comprehensive data point of E7 nations across the span 1990-2018. Relative to their territorial circumstances and many agricultural commodities provided, along with their economic progress and extensive use of clean energy and energy utilization, the study of the position of agricultural additional value, real GDP, clean energy intake on $CO_2$ pollution and the development of the EKC phenomenon fills this void and adds to the analytical research.

The trajectory of the highlighted literature survey shows a vacuum in the extant literature for the need to explore the connection between Argic value-added and $CO_2$ in a comprehensive manner. There have been vast theoretical studies such as (Soytas & Sari, 2009, Bekun et al.2019a, b). The intuition of the carbon-income function is premised on the environmental Kuznets Curve phenomenon that expresses the relationship between environmental degradation and income level. Our study advances the arguments by augmenting the conventional liner carbon-income model with agriculture as a key determinant of GHGs for the case of E7. This study employs robust and econometric analysis consistent with literature such as Pool mean group autoregressive distributed lag (PMG-ARDL), dynamic ordinal least square (DOLS) and full modified ordinary least square (FMOLS) for long –run regression among the outlined study variables while for detection of causality direction Dumitrescu and Hurlin causality test is employed. Our study relies on first-generation panel analysis on the premise of the Pesaran (2015) cross-sectional dependency (CD) test that is a common shock effect among the blocs investigated for robustness purpose as well as avoid spurious analysis. In particular, this study varies from those of Ben Jebli and Ben Youssef (2017b) and Liu, Zhang and Bae (2017), primarily because we use a separate data collection, which included comprehensive data of E7 nations across the span 1990-2016.

## 3. Data and Methods

### 3.1 Data and Variables

Annual frequency data was obtained from the World Bank Development Indicators database (WDI) is employed to investigate the relationship between our study outlined variables from 1990 to 2016 To this end, four-time series variables for E7 were employed to analyze the effect of agricultural value-added, energy usage, and economic growth on environmental degradation ($CO_2$ emissions). These variables include Agriculture, value added (constant 2010 US$) which was denoted as AVA. Second, GDP per capita (constant 2010 US$) which was symbolized as GDP. Third, $CO_2$ pollutant (metric tons per capita) which was denoted as $CO_2$ and fourth, Renewable energy consumption (% of total final energy consumption) which was denoted as EC. The definition of these variables, their value, symbol and sources are appended in Table 1. The overview of E7 nations discussed in this study comprises China, India, Brazil, Mexico, Russia, Indonesia and Turkey.

*Table 1. Description of Variables*

| Name of Indicator | Abbreviation | Proxy/Scale of Measurement | Source |
|---|---|---|---|
| Carbon dioxide emissions per capita | $CO_2$ | measured in metric tonnes | WDI |
| Gross Domestic Product | GDP | Constant of 2010 US$ | WDI |
| Agriculture value-added | AVA | constant 2010 US$ | WDI |
| Renewable energy consumption | EC | % of total final energy consumption | WDI |

Note. WDI represents the World Bank Development Indicator of the World Bank database sourced from https://data.worldbank.org/

### 3.2 Model and Methods

This study sets to investigate the contribution of agricultural value addition, GDP and energy consumption to emissions in the E7 countries. As shown in the literature review, several studies have been carried out in this area, we attempt to investigate the nexus between our study variables for E7 countries for some distinct reasons.

First, E7 countries are responsible for the second-highest contribution by economic integration globally being outperformed by the G7 alone[2]. Hence, to understand the relationship between large scales economic activities and emissions will help in no small way in pursuing a global reduction in $CO_2$ emissions and the UN-SDGs globally. Second, on the other hand, the E7 countries are responsible for a huge share of global $CO_2$ emissions, thus it is necessary to understand the contributing factors to such high emissions to enable a reduction in global emissions leading to an improvement in the natural environment and a healthier living environment.

In particular, this study varies from those of Ben Jebli and Ben Youssef (2017b) and Liu, Zhang and Bae (2017), primarily because we use a separate data collection, which included comprehensive data of E7 nations across the span 1990-2016. The extensive period covered in the study gives room for sufficient observations to draw policy inferential conclusions. Also, several environmentally relevant policy meetings such as the first Copenhagen climate summit 2009 and its succeeding conferences as well as global climate meetings such as the Kyoto protocol and other significant meetings have been held within the study period. This then enables the study to measure the implementation of resolutions from this meeting in mitigating global warming by way of reducing emissions. This study considering the position of agricultural additional value, real GDP, clean energy intake on $CO_2$ pollution and the development of the EKC proposes the following model equations:

$$LNCO_2 = f\,(LNAVA,\ LNEC,\ LNGDP) \qquad (1)$$

$$LNCO_{2it} = \alpha_0 + \beta_1 LNAVA_{it} + \beta_2 LNEC_{it} + \beta_3 LNGDP_{it} + \varepsilon_{it} \qquad (2)$$

2. Emerging Economies Will Hold Increasing Amounts of Global Economic Power by 2050. https://globalsecurityreview.com/will-global-economic-order-2050-look-like/

The logarithmic transformation has been performed to enable the variables in the current studies to maintain constant variance across all the series highlighted in our study. Where $LNCO_2$, *LNAVA, LNEC, LNGDP* are logarithmic transformations of all variables and $\varepsilon_{it}$ , α and β's represents the stochastic, intercept, and partial slope coefficients respectively.

To ascertain whether to apply the first-generation or the second-generation panel data econometric technique, the cross-sectional dependency (CD) test was carried out. The estimators are incomplete, contradictory and useless if the CD is not considered (Donget et al. 2018; Nathaniel et al, 2020). The study used the Pesaran (2015) CD test for robustness purpose. The CD test takes a null hypothesis of no cross-sectional dependence and the equation is specified as:

$$CD_p = \left(\frac{1}{N(N-1)}\right)^{\frac{1}{2}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij}\hat{\gamma}_{ij} \rightarrow N(0.1)$$

Consequently, three estimation techniques are utilized in this study, FMOLS, DOLS, and the Pooled Mean Group-ARDL by Pedroni (2004, 2001) and Kao and Chiang (2000), and Pesaran et al. (1999) respectively. Interestingly, the DOLS can correct for correlation between the dependent variable and the stochastic term it also adds lags of the independent variables. Before the estimation of relationship estimation, we conduct the unit root test of the outlined variables to ascertain the stationarity properties of the variables and avoid the pitfall of spurious regression. This study relies on first-generation panel unit root as supported by the CD test (Nathaniel et al, 2020a, b)

The DOLS is estimated using Eq 2. which is given as:

$$LnCO_{2it} = \mu_i + x_{i,t}\Psi_{i,t} + \sum_{j=-p}^{p}\beta_j\, LNC02_{i.t-j} + \sum_{j=-q0}^{q0} p_{1.j}\, LNAVAGDP_{i.t-j} + p_{2.j}\sum_{j=-q1}^{q1} LNEC_{i.t-j} + p_{3.j}\sum_{j=-q2}^{q2} LNGDP_{i.t-j} + \varepsilon_{it} \qquad (4)$$

$p$ and $q$ are the numbers of leads/lags. The long-run relationship is estimated from the FMOLS equation given as:

$$\mathrm{LnCO2}_{i,t} = \mu_{i,t} + x_{i.t}\psi + v_{it} \qquad (5)$$

$$x_{i.t} = x_{i.t} + \mathfrak{C}_{i.t}$$

Where $x$ 5*1 vector of explanatory variables is, $\mu_i$ is the intercept while $\mathfrak{C}_{i.t}$ and $v_{it}$ are the error terms. However, the estimation of $\psi$ is expressed as:

$$\hat{\psi}_{FMOLS} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{i.t} - \bar{x}_{i.t}) * (x_{i.t} - \bar{x}_{i.t})'\right)^{-1} * \left(\sum_{i=1}^{N} \left(\sum_{t=1}^{T}(x_{i.t} - \bar{x}_{i.t}) * \widehat{LNC02}_{it} - T\hat{\Delta}_{v\mathfrak{C}}\right)\right) \qquad (6)$$

The researchers also examined both short-and long-term forecasts utilizing the Pesaran et al. (1999) method. The study proceeded with the evaluation of agricultural value added-GDP-Energy-emissions nexus identified in Eq. (1) in the Autoregressive Distributed Lag (ARDL: p, q) system that integrates all pollution lags including Regressors, provided that:

$$LnC02_{it} = \beta_i \quad + \sum_{j=0}^{p} \delta_{ij}\, LNCO2\, Z_{it-j} + \sum_{j=1}^{q} \quad \varphi\delta_{i,j} Z_{it-j} + \varepsilon_{it} \qquad (7)$$

Where, $Z_{it}$ = ($LnAVA_{it}$, $LnEC_{it}$, $LnGDP_{it}$) is a function for the explanatory variables used in this analysis. $\beta i$ indicates the country-level fixed results, $\delta ij$ indicates the slope of the lagged pollution vector and $\varphi i$, j indicates the slope of the lagged explanatory variables.

The PMG-ARDL co-integration methodology has important econometric strengths relative to conventional panel data models. It could fix endogeneity problems in econometric models and at the same time handle either short-or long-term parameters. The ARDL co-integration method is also capable of taking into account variables in a combined integration order, such as I(0) or/and I (1) but not I (2). Pesaran et al. (1999) also reported that the Pool Mean Group (PMG) estimator is accurate, resilient and high to lag orders and outliers.

## 4. Results and Discussions

### 4.1 Pre-estimation Diagnostics

This section reports the discussion of the study regression and stylized implications accordingly. The section setoff with basic summary statistics of the outlined variables as reported in Table 2 that comprises of measure of central tendencies and dispersion like average, median, mean deviation, standard deviation range and mode and subsequently correlation Pearson correlation analysis on the pairwise relationship between variables. As earlier mentioned in the introduction section, variables were informed by the UN-SDGs vision 2030. The econometrics modelling is further informed by economic intuition and empirical backing of modelling general-to-specific modelling test. Additionally, to avoid multicollinearity, the Pearson correlation analysis serves as a guide. The present study correlation analysis is satisfactory as no extreme correlation seen to pose a threat to econometrics analysis. The variance inflation factor (VIF) or tolerance factor, which is the inverse of VIF, resonates the position of Pearson correlation analysis (see Appendix for VIF/I/VIF results). From table 1 below, the summary statistics of the E7 states reveal that Agriculture value addition has the highest mean of 25.25%, a median of 25% and a maximum of 27.3% value. The result shows that $CO_2$ produce 1.08 metric tons of emissions as a mean, a median of 1.01 metric tons and a maximum of 2.63 metric tons of pollutant per year. Moreover, the mean growth per year was 8.4%, a median of 8.9% and a maximum of 9.6%. Renewable energy consumption has a mean of 3.0 metric tons of emission produce per year, a median of 3.2 metric tons and a maximum of 4.1 metric tons per year. Nevertheless, table 3 which show how correlated the variables are proof that there is a negative correlation regarding $CO_2$, agriculture value-added and energy consumption but a positive correction regarding agriculture value-added and real GDP. Agriculture value added has a negative correction with real GDP but positive correction with energy consumption. Real GDP on the other hand has a negative correction with energy consumption.

Table 2. Summary Statistics

| | $LNCO_2$ | LNAVA | LNGDP | LNEC |
|---|---|---|---|---|
| Mean | 1.083766 | 25.25140 | 8.415671 | 2.994691 |
| Median | 1.013691 | 24.99841 | 8.882699 | 3.199113 |
| Maximum | 2.637626 | 27.29698 | 9.551284 | 4.071636 |
| Minimum | -0.343899 | 23.94471 | 6.355242 | 1.171799 |
| Std. Dev. | 0.777889 | 0.881508 | 0.915770 | 0.907475 |
| Skewness | 0.304724 | 0.661540 | -0.763776 | -0.695471 |
| Kurtosis | 2.273311 | 2.361353 | 2.208560 | 2.272043 |
| Jarque-Bera | 7.083594 | 16.99747 | 23.30835 | 19.40905 |
| Probability | 0.028961 | 0.000204 | 0.000009 | 0.000061 |
| Sum | 204.8318 | 4772.515 | 1590.562 | 565.9967 |
| Sum Sq. Dev. | 113.7608 | 146.0866 | 157.6634 | 154.8200 |
| Observations | 189 | 189 | 189 | 189 |

Source: Authors computation with data from WDI

Table 3. Correlation matrix Analysis

| VARIABLES | $LNCO_2$ | LNAVA | LNGDP | LNEC |
|---|---|---|---|---|
| $LNCO_2$ | 1.0000 | | | |
| p-value | - | | | |
| LNAVA | -0.242858*** | 1.0000 | | |
| p-value | (0.0008) | -- | | |
| LNGDP | 0.633316*** | -0.635632*** | 1.0000 | |
| p-value | (0.0000) | (0.0000) | - | |
| LNEC | -0.953087*** | 0.362113*** | -0.560876*** | 1.0000 |
| p-value | (0.0000) | (0.0000) | (0.0000) | --- |

Note: ***, ** and * are 1%, 5% and 10% significant level respectively

Subsequently, after accessing the correlation among the variables, it was important to proof with evidence of CD in the constructs as presented in Table 4. With the outcome, the analysis cannot proceed with analytical techniques that are robust with CD test but techniques that are robust with a first-generation test because both of the CD techniques use were not significant.

Table 4. Cross-sectional Dependency test

| **Dependent/ models** | **Pesaran (2015) CD** |
|---|---|
| **$LNCO_2$=f(LNAVA,LNGDP, LNEC)** | 1.529 (0.126) |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

It was therefore important to run the first-generation unit root to access stationary among the variables. Following the outcome of the unit root test- the ADF and Philips Perron unit root tests in Table 5, it is revealed that all variables are stable at first difference while only Real GDP is stationary at level. On the other hand, the Pedroni, Johansen Fisher and Kao residual and ADF cointegration tests as reported in tables 6, 7 and table 8 all respectively affirm equilibrium relationship between the outlined variables, we see that there exists a long-run relationship among the variables at various levels of significance.

**Table 5. Unit root Test**

| | ADF | | | | PP | | | |
|---|---|---|---|---|---|---|---|---|
| | **AT LEVEL** | | **AT $1^{ST}$ LEVEL** | | **AT LEVEL** | | **AT $1^{ST}$ LEVEL** | |
| VARIABLES | $\pi\tau$ | $\pi\vartheta$ | $\pi\tau$ | $\pi\vartheta$ | $\pi\tau$ | $\pi\vartheta$ | $\pi\tau$ | $\pi\vartheta$ |
| $LNCO_2$ | 0.8710 | 0.0241** | 0.1316*** | 0.2529*** | 0.8734 | 0.6565* | 0.0002*** | 0.0014*** |
| LNAVA | 0.8983 | 0.0085 | 0.0000*** | 0.0000 | 0.9734 | 0.0073 | 0.0000*** | 0.0000*** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LNGDP | 1.0000 | 0.3170 | 0.0010** | 0.0016** | 1.0000 | 0.3113 | 0.0008** | 0.0000** |
| LNEC | 0.9664 | 0.6397 | 0.0489*** | 0.1470*** | 0.9881 | 0.8112 | 0.0521*** | 0.1497*** |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively Note: ***, ** and * are 1%, 5% and 10% significant level respectively; thus, $\pi\tau$ is with constant, $\pi\vartheta$ is with constant and trend.**

Table 6. Pedroni Cointegration Test

| Deterministic intercept and trend | | | | | |
|---|---|---|---|---|---|
| | **Weighted stat** | **p-value** | | **Statistic** | **p-value** |
| **Panel v-Stat** | -0.553170 | (0.7099) | Group rho-Stat | 0.338732 | (0.6326) |
| **Panel rho-Stat** | -0.265955 | (0.3951) | Group PP-Stat | -2.604123*** | (0.0046) |
| **Panel PP-Stat** | -2.929334*** | (0.0017) | Group ADF-Stat | -1.183671 | (0.1183) |
| **Panel ADF-Stat** | -2.311594** | (0.0104) | | | |

| No deterministic trend | | | | | |
|---|---|---|---|---|---|
| | **Weighted stat** | **p-value** | | **Statistic** | **p-value** |
| **Panel v-Stat** | 0.680441 | (0.2481) | Group rho-Stat | 0.136768 | (0.5544) |
| **Panel rho-Stat** | -0.981008 | (0.1633) | Group PP-Stat | -1.197786 | (0.1155) |
| **Panel PP-Stat** | -2.094124** | (0.0181) | Group ADF-Stat | -0.338211 | (0.3676) |
| **Panel ADF-Stat** | -1.484271* | (0.0689) | | | |

| No deterministic intercept or trend | | | | | |
|---|---|---|---|---|---|
| | **Weighted stat** | **p-value** | | **Statistic** | **p-value** |
| **Panel v-Stat** | 1.128436 | (0.1296) | Group rho-Stat | 0.340570 | (0.6333) |
| **Panel rho-Stat** | -0.922422 | (0.1782) | Group PP-Stat | -0.734678 | (0.2313) |
| **Panel PP-Stat** | -1.564818* | (0.0588) | Group ADF-Stat | -1.142523 | (0.1266) |
| **Panel ADF-Stat** | -1.873939** | (0.0305) | | | |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

Table 7. Johansen Fisher Panel Cointegration Test

| HYPOTHESIS NO. OF CE(S) | FISHER STAT (from trace) | p-value | FISHER STAT (from max-eight**)** | p-value |
|---|---|---|---|---|
| r≤0 | 66.69*** | (0.0000) | 45.92*** | (0.0000) |
| ≤1 | 32.81*** | (0.0031) | 25.02** | (0.0344) |
| r ≤2 | 17.04 | (0.2539) | 13.26 | (0.5060) |
| r ≤3 | 24.28** | (0.0424) | 24.28** | (0.0424) |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

**Table 8. Kao's (1999) residual cointegration test results**

| | t-Statistic | p-value |
|---|---|---|
| ADF | -2.812093*** | (0.0025) |
| Residual variance | 0.002875 | |
| HAC variance | 0.003233 | |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

## 4.2 Empirical Results Discussion

In table 9 below, we report long-run estimates of the Pooled mean group autoregressive distributed lag (PMG-ARDL), dynamic ordinal least square (DOLS) and fully modified ordinal least square (FMOLS) estimates. As expected, the coefficient for agricultural value added is positive and significant at 1% which means that Agricultural value added is a driver of $CO_2$ emissions in the long run. Specifically, a 1% rise in Agricultural value addition will increase emissions between the ranges of 0.31% to 0.80%. This is because the more agricultural production, the more demand for the use of combustible energy resources which leads to the release of emissions into the environment. This finding is similar to that of Ben Jebli and Ben Youssef (2017a) for Tunisia and Liu et al. (2017) for 4 ASEAN countries.

On the other hand, energy use in the form of renewable energy utilization has a negative and significant coefficient at varying levels of significance. Specifically, a 1% rise in energy use will lead to a reduction in $CO_2$ emissions by 0.32% to 0.66% in the E7 countries. This outcome is not as expected as high energy consumption is often associated with high emissions. However, the negative relationship between energy use and emissions points to the sustained consumption of a significant amount of renewable energy in the E7 countries which further points to the commitment of the E7 countries to attain a cleaner environment. Similar findings have been documented by Ben Jebli and

Ben Youssef (2015a) for Tunisia and Bölük and Mert (2015) for Turkey and Gyamfi et al (2021b) for the same E7 economics.

As expected, the coefficients for Economic growth is positive and significant at a 1% level of significance. Specifically, a 1% increase in economic growth will lead to an increase in emissions by 0.267% to 0.307% in the focus countries. Given the high volume of economic activities in the E7 countries, high emissions are emanating from the processing and manufacturing industries in the bloc, which leads to the depletion of environmental quality. Similar to Bouznit and Pablo-Romero (2016) for Algeria and Ahmad et al. 2016 for Croatia and Gyamfi et al (2020d, e).

Table 10 shows, the short-run relationship between the dependent variables $CO_2$ emissions using the PMG-ARDL estimator. Gross Domestic Product still has a positive and significant coefficient which implies a positive and significant relationship between economic and emissions. Specifically, a 1% increase in economic growth will cause a rise in emissions by 0.52% in the short run in the E7 countries. Consequently, agricultural value addition and Energy use do not have a significant impact on emissions in the short run implying that it takes a longer period before agriculture value addition and energy use causes a significant impact on emissions in the E7 countries.

Table 9. Long-run results PMG-ARDL, DOLS and FMOLS

| VARIABLES | ARDL (2, 1, 1, 1) | DOLS | FMOLS |
|---|---|---|---|
| LNAVA | 0.800113*** | 0.305835*** | 0.395461*** |
| p-value | (0.0000) | (0.0018) | (0.0000) |
| LNGDP | 0.068672 | 0.303739*** | 0.255714*** |
| p-value | (0.4962) | (0.0004) | (0.0006) |
| LNEC | -0.660065*** | -0.318041*** | -0.337560*** |
| p-value | (0.0000) | (0.0008) | (0.0001) |
| R-SQUARE | | 0.995407 | 0.989451 |
| ADJ R-SQUARE | | 0.991927 | 0.988899 |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

*Table 10. Results of Short-run ARDL (2, 1, 1, 1)*

| SHORT-RUN EQUATION | | | |
|---|---|---|---|
| VARIABLES | **COEFFICIENT** | **STD. ERROR** | **t-STATISTIC** |
| COINTEQ01 | -0.327525** | 0.149874 | -2.185336 |
| D(LNCO$_2$(-1)) | 0.140419 | 0.110559 | 1.270089 |
| D(LNAVA) | -0.107415 | 0.089569 | -1.199236 |
| D(LNGDP) | 0.516560*** | 0.196576 | 2.627785 |
| D(LNEC) | -0.299346 | 0.315816 | -0.947852 |
| Constant | -5.658413** | 2.584261 | -2.189567 |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively**

### 4.3 Heterogeneous Causality Test

The Dumitrescu and Hurlin Causality tests for the variables in the study are reported in table 11. Results reveal that there is no causality between LNC0$_2$ and LNAVA and LNEC. While there is Bi-directional causality from LNAVA to LNCO$_2$. This bidirectional causality shows that while higher levels of emissions will require more focus on the agricultural sector, there is a potential rise in emissions due to higher levels of emission-generating machinery been used in the E7 countries. This also confirms the findings of Jebli and Ben Youssef (2017a; 2017b) examination in Tunisia from 1980 to 2011. Again, there is a bi-directional relationship between LNAVA to LNEC which fail to confirm the finding of Sebri and Abid (2012) proving a uni-directional causality regarding agricultural value-added and energy utilization. Moreover, LNAVA to LNGDP also prof a bi-directional causality by confirming the analysis of Jebli and Ben Youssef (2017b). Lastly, there is bi-directional causality between LNCO$_2$ to LNGDP which again affirms the finding of Gyamfi et al, (2020a). Moreover, there is a uni-directional causal relation between real GDP and pollutant emissions. This implies that, while economic growth causes emissions, emissions can also predict economic growth. Moreover, Agriculture value added also causes emissions. However, energy use does not cause emissions directly but it causes economic growth which causes emissions.

Table 11. Dumitrescu and Hurlin Causality Test

| **Null Hypothesis:** | **Z-bar Stat** | **p-value** | **Causality Remark** |
|---|---|---|---|
| **LNAVA ≠ LNCO$_2$** | 3.58601*** | (0.0003) | Bi-directional causality |
| **LNCO$_2$ ≠ LNAVA** | 5.27304*** | (1.E-07) | |
| **LNEC ≠ LNCO$_2$** | 1.50659 | (0.1319) | No causality |
| **LNCO$_2$ ≠ LNEC** | 0.63750 | (0.5238) | |
| **LNGDP ≠ LNCO$_2$** | 3.67205*** | (0.0002) | Uni-directional causality |
| **LNCO$_2$ ≠ LNGDP** | 1.62267 | (0.1047) | |
| **LNEC ≠ LNAVA** | 3.96118*** | (7.E-05) | Bi-directional causality |
| **LNAVA ≠ LNEC** | 3.56245*** | (0.0004) | |
| **LNGDP ≠ LNAVA** | 4.77383*** | (2.E-06) | Bi-directional causality |
| **LNAVA ≠ LNGDP** | 2.31318** | (0.0207) | |
| **LNGDP ≠ LNEC** | 1.37200 | (0.1701) | No causality |
| **LNEC ≠ LNGDP** | 1.20824 | (0.2270) | |

**Note: ***, ** and * are 1%, 5% and 10% significant level respectively while ≠ represents does not "Granger cause"**

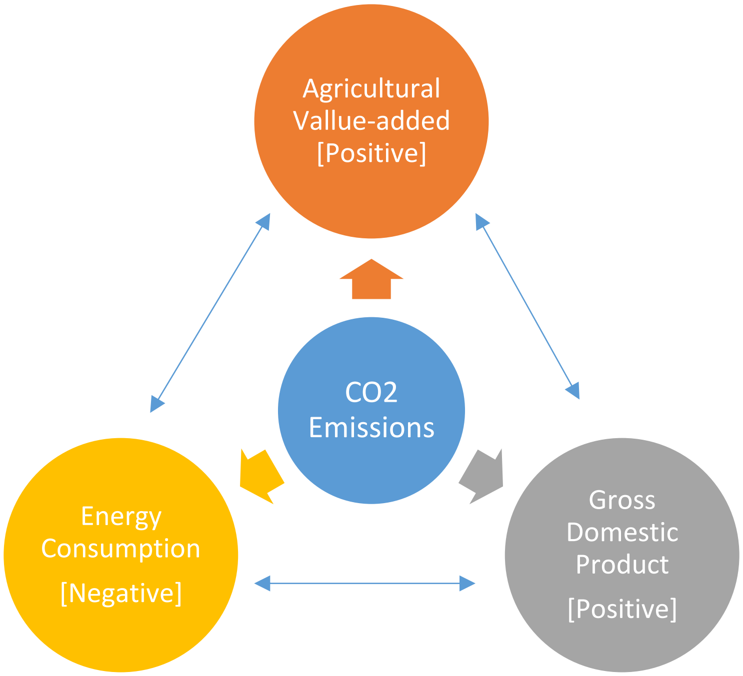

FIG.1 ↔ Represents Bidirectional causality

## 5. Conclusion and Policy Implications

Several studies have been carried out on the nexus between agriculture value addition, energy use, economic growth and emissions. However, this study differs by complementing the extant literature in considering the role of clean energy in a carbon-income function for the case of E7 countries namely (China, India, Brazil, Mexico, Russia, Indonesia and Turkey) for the period 1990 to 2016). The study utilized the PMG-ARDL, DOLS and FMOLS estimators and Dumitrescu and Hurlin Causality Test. According to the findings, long-run regression estimates revealed that Agricultural value-added and economic growth are drivers of $CO_2$ emissions in the E7 countries while the rise in energy causes a reduction in $CO_2$ emissions. While in the short-run economic growth has a positive impact on emissions in E7 countries while value-added and energy use has no impact on emissions in the short run. Causality tests showed that there is a feedback effect between economic growth and emissions, energy usage and Agriculture value-added, emissions and agriculture value-added as well as agriculture value-added and economic growth. A one-way direction of causality also exists between economic growth and pollutant emissions. Also, energy consumption does not cause emissions directly, it causes economic growth, and Agriculture value added which causes emissions.

As per policy recommendations, an increase in agricultural production is desirable, but the use of renewable energy in agricultural production is necessary to attain optimum agricultural products without damaging the quality of the environment. To further achieve fewer emissions, the increased use of renewable energy is encouraged in the E7 countries especially for economic activities given that the bloc is a huge economic and industrial hub. Additionally, this study demonstrates that agriculture-value added leads to pollutant pollution in countries such as China, Indonesia, India, Brazil, Mexico, Russia and Turkey (E7) that produce a large number of pollutions. Therefore, a policy that targets the reduction of farm activities that form part of emissions, such as bush burning is necessary. Bush fire should be deterred; alternatively, better agricultural methods that involve less land utilization such as greenhouse agriculture should be introduced. Also, brush and weed de-composition must be embraced, which can serve as fertilizers. Nevertheless, the desire for E7 authorities to reinforce ecological agreements and laws in their institutions is also necessary to prevent environmental degradation and reducing emissions of GHG's. This will go a long way to achieve high economic growth and at the same time, high quality in the environment which resonates with the United Nations Sustainable development goals (UN-SDGs) targets 7, 12 and 13 of clean energy access and mitigation of climate changes issues.

## Reference

Adedoyin FF, Alola AA, Bekun FV, (2020a). An assessment of environmental sustainability corridor: The role of economic expansion and research and development in EU countries. Sci. Total Environ. 713, 136726. https://doi.org/10.1016/j.scitotenv.2020.136726

Adedoyin FF, Gumede IM, Bekun VF, Etokakpan UM, Balsalobre-lorente D, (2020b). Modelling coal rent , economic growth and CO 2 emissions : Does regulatory quality matter in BRICS economies ? Sci. Total Environ. 710, 136284. https://doi.org/10.1016/j.scitotenv.2019.136284

Agboola MO, & Bekun F V, (2019). Does agricultural value added induce environmental degradation? Empirical evidence from an agrarian country. Environmental Science and Pollution Research, 26(27), 27660-27676.

Ahmad NL, Du J, Lu J, Wang H.-Z, Li, and MZ, Hashmi (2016). "Modelling the CO2 Emissions and Economic

Apergis N, and I. Ozturk, (2015). "Testing Environmental Kuznets Curve Hypothesis in Asian Countries." Ecological Indicators 52: 16–22. doi:10.1016/j.ecolind.2014.11.026

Aydoğan, B., & Vardar, G. (2020). Evaluating the role of renewable energy, economic growth and agriculture on CO2 emission in E7 countries. *International Journal of Sustainable Energy*, *39*(4), 335-348.

Baek J, (2015). "A Panel Cointegration Analysis of CO2 Emissions, Nuclear Energy and Income in Major Nuclear Generating Countries." Applied Energy 145: 133–138. doi:10.1016/j.apenergy.2015.01.074.

Balsalobre-Lorente D, Driha OM, Bekun FV, & Osundina OA, (2019). Do agricultural activities induce carbon emissions? The BRICS experience. Environmental Science and Pollution Research, 26(24), 25218-25234.

Bekun FV, Alola AA, & Sarkodie SA, (2019a). Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. Science of the Total Environment, 657, 1023-1029.

Bekun FV, Emir F, & Sarkodie SA, (2019b). Another look at the relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa. Science of the Total Environment, 655, 759-765.

BEKUN, F. V., & GYAMFI, B. A. (2020c). Rethinking the nexus between pollutant emission, financial development, renewable energy consumption and economic growth in G7 countries. *SOCIAL, HUMAN AND ADMINISTRATIVE SCIENCES-II*, 73.

Ben Jebli M, and S. Ben Youssef (2015b). "Output, Renewable and Non-renewable Energy Consumption and International Trade: Evidence from a Panel of 69 Countries." Renewable Energy 83: 799–808. doi:10.1016/j. renene.2015.04.061

Ben Jebli M, and S. Ben Youssef (2017a). "Renewable Energy Consumption and Agriculture: Evidence for Cointegration and Granger Causality for Tunisian Economy." International Journal of Sustainability Development & World Ecology 24: 149–158. doi:10.1080/13504509.2016.1196467.

Ben Jebli M, and S. Ben Youssef, (2015a). "The Environmental Kuznets Curve, Economic Growth, Renewable and Nonrenewable Energy, and Trade in Tunisia." Renewable & Sustainable Energy Reviews 47: 173–185. doi:10. 1016/j.rser.2015.02.049

Ben Jebli M, and S. Ben Youssef, (2017b). "The Role of Renewable Energy and Agriculture in

Reducing CO2 Emissions: Evidence From North Africa Countries.” Ecological Indicators 74: 295–301. doi:10.1016/j.ecolind.2016.11.032

Ben Jebli M, S. Ben Youssef, and I. Ozturk, (2015). “The Role of Renewable Energy Consumption and Trade: Environmental Kuznets Curve Analysis for Sub-Saharan Africa Countries.” African Development Review Revue Africaine Developpement 27: 288–300. doi:10.1111/1467-8268.12147

Best G, (1998). Energizing the Food Production Chain for the Attainment of Food Security. In Sustainable Agriculture for Food Security, Energy and Industry (pp. 1123–1129). London: James and James

Blanco, G., Gerlagh, R., Suh, S., Barrett, J., de Coninck, H. C., Morejon, C. D., & Pathak, H. (2014). Drivers, trends and mitigation. Cambridge University ,Press: Cambridge.

Bloomberg New Energy Finance Report. (2016). “Global Trends in Renewable Energy Investment.” Frankfurt SchoolUNEP Centre/BNEF

Bölük, G, and M. Mert, (2015). “The Renewable Energy, Growth and Environmental Kuznets Curve in Turkey: An ARDL Approach.” Renewable & Sustainable Energy Reviews 52: 587–595. doi:10.1016/j.rser.2015.07.138

Bouznit M, and MDP, Pablo-Romero, (2016). “CO2 Emission and Economic Growth in Algeria.” Energy Policy 96: 93–104. doi:10.1016/j.enpol.2016.05.036.

Breusch TS, and Pagan AR., (1980). The Lagrange Multiplier test and its applications to model specification in econometrics. Rev Econ Stud; 47:239e53. https:// doi.org/10.2307/2297111

Chebbi HE, (2010). “Long and Short-run Linkages Between Economic Growth: Energy Consumption and CO2 Emissions in Tunisia.” Middle East Development Journal 1: 139–158. doi:10.1142/S1793812010000186

Chebbi HE, M, Olarreaga, and H. Zitouna, (2011). “Trade Openness and CO2 Emissions in Tunisia.” Middle East Development Journal 3: 29–53. doi:10.1142/S1793812011000314

Danish Zhang B, B. Wang, and Z. Wang (2017). “Role of Renewable Energy and Non-renewable Energy Consumption on EKC: Evidence from Pakistan.” Journal of Cleaner Production 156: 855–864. doi:10.1016/j.jclepro.2017.03.203.

Dong K, Sun R, Li H, Liao H (2018) Does natural gas consumption mitigate CO 2 emissions: testing the environmental Kuznets curve hypothesis for 14 Asia-Pacific countries. Renew Sust Energ Rev 94:419–429

Etokakpan, M. U., Solarin, S. A., Yorucu, V., Bekun, F. V., & Sarkodie, S. A. (2020). Modeling natural gas consumption, capital formation, globalization, CO2 emissions and economic growth nexus in Malaysia: Fresh evidence from combined cointegration and causality analysis. Energy Strategy Reviews, 31, 100526.

FAO, (2016). “The State of Food and Agriculture Climate Change, Agriculture and Food Security.” Rome. http://www. fao.org/3/a-i6030e.pdf.

FAO, (2017). “The Future of Food and Agriculture – Trends and Challenges.” Rome. http://www.fao.org/3/a-i6583e.pdf.

Farhani S, and M. Shahbaz, (2014). “What Role of Renewable and Non-renewable Electricity Consumption and Output Is Needed to Initially Mitigate CO2 Emissions in MENA Region?” Renewable & Sustainable Energy Reviews 40: 80–90. doi:10.1016/j.rser.2014.07.170.

Growth in Croatia: Is There Any Environmental Kuznets Curve?” Energy 123: 164–172. doi:10.1016/j.energy.2016.12.106

Gyamfi BA, Bein AM, Bekun V F., (2020a). Investigating the nexus between hydroelectricity energy, renewable energy, non-renewable energy consumption on output: evidence from E7 countries. Environmental Science and Pollution Research https://doi.org/10.1007/s11356- 020-08909-8

Gyamfi, B. A., Adedoyin, F. F., Bein, M. A., & Bekun, F. V. (2021c). Environmental implications of N-shaped environmental Kuznets curve for E7 countries. *Environmental Science and Pollution Research*, 1-11.

Gyamfi, B. A., Adedoyin, F. F., Bein, M. A., Bekun, F. V., & Agozie, D. Q. (2021b). The Anthropogenic Consequences of Energy consumption in E7 Economies: Juxtaposing roles of Renewable, Coal, Nuclear, Oil and Gas Energy: Evidence from Panel Quantile Method. *Journal of Cleaner Production*, 126373.

Gyamfi, B. A., Bein, M. A., Ozturk, I., & Bekun, F. V. (2020e). The moderating role of employment in an environmental Kuznets curve framework revisited in G7 countries. *Indonesian Journal of Sustainability Accounting and Management*, *4*(2).

Gyamfi, B. A., Sarpong, S. Y., & Bein, M. A. (2020d). The contribution of the anthropogenic impact of biomass utilization on ecological degradation: revisiting the G7 economies. *Environmental Science and Pollution Research*, 1-14.

Iwata H, K. Okada, and S. Samreth (2011). "A Note on the Environmental Kuznets Curve for CO2: A Pooled Mean Group Approach." Applied Energy 88: 1986–1996. doi:10.1016/j.apenergy.2010.11.005.

Karkacier O, ZG. Goktolga, and A. Cicek, (2006). "A Regression Analysis of the Effect of Energy Use in Agriculture." Energy Policy 34 (18): 3796–3800. doi:10.1016/j.enpol.2005.09.001

Kaygusuz K, (2007). "Energy for Sustainable Development: Key Issues and Challenges." Energy Sources, Part B: Econonomics, Planning and Policy 2: 73–83. doi:10.1080/15567240500402560.

Kaygusuz K, O. Yuksek, and A. Sari, (2007). "Renewable Energy Sources in the European Union: Markets and Capacity." Energy Sources, Part B: Econonomics, Planning and Policy 2: 19–29. doi:10.1080/15567240500400887

Kirikkaleli D, Adedoyin FF, Bekun FV, (2020). Nuclear energy consumption and economic growth in the UK: Evidence from wavelet coherence approach. J. Public Aff. 1–11. https://doi.org/10.1002/pa.2130

Lin B, OE. Omoju, NM. Nwakeze JU. Okonkwo, and ET. Megbowon, (2016). "Is the Environmental Kuznets Curve Hypothesis a Sound Basis for Environmental Policy in Africa?" Journal of Cleaner Production 133: 712–724. doi:10.1016/j.jclepro.2016.05.173.

Mushtaq K, F. Abbas, and A. Abdul Ghafour, (2007). "Energy Use for Economic Growth: Cointegration and Causality Analysis from the Agriculture Sector of Pakistan." The Pakistan Development Review 46: 1065–1073. http://www. pide.org.pk/pdf/PDR/2007/Volume4/1065-1073.pdf

Nathaniel, S., & Khan, S. A. R. (2020b). The Nexus between Urbanization, Renewable Energy, Trade, and Ecological Footprint in ASEAN Countries. Journal of Cleaner Production, 122709.

Nathaniel, S., Aguegboh, E., Iheonu, C., Sharma, G., & Shah, M. (2020a). Energy consumption, FDI, and urbanization linkage in coastal Mediterranean countries: re-assessing the pollution haven hypothesis. *Environmental Science and Pollution Research*, 1-14.

Pesaran, M.H., (2007). A simple panel unit root test in the presence of cross-section dependence. J. Appl. Econom. 22 (2), 265–312.

PWC, (2017). "The Long View. How Will the Global Economic Order Change by 2050?" The World in 2050. February. https://www.pwc.com/gx/en/world-2050/assets/pwc-world-in-2050-summary-report-feb-2017.pdf.

Qureshi MI, MA. Hassan, SS. Hishan, AM. Rasli, and K. Zaman, (2017). "Dynamic Linkages between Sustainable Tourism, Energy, Health and Wealth: Evidence from Top 80 International Tourist Destination Cities in 37 Countries." doi:10.1016/j.jclepro.2017.05.001

Rafiq S, R. Salim, and N. Apergis, (2016). "Agriculture: Trade Openness and Emissions: An Empirical Analysis and Policy Options." The Australian Journal of Agricultural and Resource Economics 60: 348–365. doi:10.1111/1467- 8489.1213

Reynolds L, and S. Wenzlau, (2012). "Climate-friendly Agriculture and Renewable Energy: Working Hand-in-hand Toward Climate Mitigation." Worldwatch Institute. https://www.renewableenergyworld.com/articles/2012/12/ climate-friendly-agriculture-and-renewable-energy-working-hand-in-hand-toward-climate-mitigation.html.

Saboori B, J. Bin Sulaiman, and S. Mohd, (2012). "An Empirical Analysis of the Environmental Kuznets Curve for CO2 Emissions in Indonesia: The Role of Energy Consumption and Foreign Trade." International Journal of Economics and Financial Issues 4: 243–251. doi:10.5539/ijef.v4n2p243

Saboori B, J. Bin Sulaiman, and S. Mohd, (2016). "Environmental Kuznets Curve and Energy Consumption in Malaysia: A Cointegration Approach." Energy Sources, Part B: Economies, Planning, and Policy 11: 861–867. doi:10.1080/ 15567249.2012.662264.

Sarpong, S. Y., Bein, M. A., Gyamfi, B. A., & Sarkodie, S. A. (2020). The impact of tourism arrivals, tourism receipts and renewable energy consumption on quality of life: A panel study of Southern African region. *Heliyon*, *6*(11), e05351.

Shafiei S, and RA. Salim, (2014). "Nonrenewable and Renewable Energy Consumption and CO2 Emissions in OECD Countries: A Comparative Analysis." Energy Policy 66: 547– 556. doi:10.1016/j.enpol.2013.10.064.

Shahbaz M, R. Sbia, H. Hamdi, and I. Ozturk, (2014). "Economic Growth, Electricity Consumption, Urbanization and Environmental Degradation Relationship in United Arab Emirates." Ecological Indicators 45: 622–631. doi:10.1016/ j.ecolind.2014.05.022.

Shahbaz, M., Sinha, A., & Kontoleon, A. (2020). Decomposing scale and technique effects of economic growth on energy consumption: Fresh evidence from developing economies. International Journal of Finance & Economics

Sinha, A., & Sengupta, T. (2019). Impact of energy mix on nitrous oxide emissions: an environmental Kuznets curve approach for APEC countries. Environmental Science and Pollution Research, 26(3), 2613-2622

Sinha, A., Shahbaz, M., & Balsalobre, D. (2017). Exploring the relationship between energy usage segregation and environmental degradation in N-11 countries. Journal of Cleaner Production, 168, 1217-1229.

Soytas, U., & Sari, R. (2009). Energy consumption, economic growth, and carbon emissions: challenges faced by an EU candidate member. Ecological economics, 68(6), 1667-1675.

Tiwari AK, (2011). "Comparative Performance of Renewable and Nonrenewable Energy Source on Economic Growth and CO2 Emissions of Europe and Eurasian Countries: A PVAR Approach." Economics Bulletin 31 (3): 2356–2372. http://www.accessecon.com/Pubs/EB/2011/Volume31/EB-11-V31-I3-P212.pdf

Turkekul B, and G. Unakitan, (2011). "A Co-integration Analysis of the Price and Income Elasticities of Energy Demand in Turkish Agriculture." Energy Policy 39: 2416–2423. doi:10.1016/j.enpol.2011.01.064.

Udi J, Bekun FV, Adedoyin FF, (2020). Modeling the nexus between coal consumption , FDI inflow and economic expansion : does industrialization matter in South Africa ? Environ. Sci. Pollut. Res.

Youssef A, Ben S. Hammoudeh, and A. Omri, (2016). "Simultaneity Modeling Analysis of the Environmental Kuznets Curve Hypothesis." Energy Economics 60: 266–274. doi:10.1016/j.eneco.2016.10.005.

Zafar, M. W., Shahbaz, M., Hou, F., & Sinha, A. (2019). From nonrenewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries. Journal of cleaner production, 212, 1166-1178

Zhang S, X. Liu, and J. Bae, (2017). "Does Trade Openness Affect CO2 Emissions: Evidence from Ten Newly Industrialized Countries?" Environmental Science and Pollution Research 24 (21): 17616–17624. doi:10.1007/ s11356-017-9392-8.

## Declarations

### Availability of data and materials

The data for this present study are sourced from the World Development Indicators (https://data.worldbank.org/). The current data specific data can be made available upon request but all available and downloadable at the earlier mentioned database and weblink

### Competing interests

I wish to disclose here that there are no potential conflicts of interest at any level of this study.

### Funding

I hereby declare that there is no form of funding received for this study.

### Authors' contributions

The first authors (Dr. Festus Fatai ADEDOYIN) was responsible for the conceptual construction of the study's idea. Second author (Prof. Dr. Murad A. Bein) handled the literature section while third authors (Asst.Prof.Dr. Festus Victor Bekun) managed the data gathering, preliminary analysis and Dr. Bright Akwasi Gyamfi was responsible for proofreading and manuscript editing.

**Ethical Approval**: Authors mentioned in the manuscript have agreed for authorship read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.

**Consent to Participate**: Note Applicable

**Consent to Publish**: Applicable

### Acknowledgments

Author gratitude is extended to the prospective editor(s) and reviewers that will/have spared time to guide toward a successful publication.

The Authors of this article also assures that they follow the springer publishing procedures and agree to publish it as any form of access article confirming to subscribe access standards and licensing.

Many thanks in advance look forward to your favorable response

Yours truly,

Authors

## Appendix

**Table A.1: VIF Estimations**

| Variables | VIF | 1/VIF |
|---|---|---|
| **LnGDP** | 2.13 | 0.470101 |
| **LnAVA** | 1.68 | 0.595926 |
| **LnREC** | 1.46 | 0.685366 |
| **Mean VIF** | 1.75 | |