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RESEARCH ARTICLE

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Macroeconomic Variables and Carbon Dioxide Emissions Nexus in Kenya

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Abstract

Ever since the times of industrial revolution, the world is racing to attain high economic development at the expense of natural resources utilization. The pursuit has led to a raise in the exploitation of non-renewable resources through various human activities leading to emissions of greenhouse gases especially carbon dioxide (CO_2) that causes global warming and eventually climate change with negative economic repercussions. This study sought to establish the macroeconomic variables and carbon dioxide emissions nexus in Kenya. The study further sought to establish the validity of Environmental Kuznets Curve for Kenya. The analysis is based on auto-regressive distributed lag model of spanning data over time series 1963 to 2017. The results revealed that an increase in the use of energy and population size worsens carbon dioxide emissions while sustainable Agriculture and industrialization reduces the prevalence of carbon dioxide percentage in the atmosphere. The study confirmed an inverted U shape confirming the validity of EKC hypothesis. The model also revealed forty five percent speed of adjustment of the disturbances from the year before in CO_2e to equilibrium in the current year. As a policy implication, the study highlights sustainable technologies like carbon arrest and storing, demeaning clean and renewable energy for domestic and industrial use, green initiatives in building and construction, sustainable agriculture focusing on productivity and engaging the public on environmental preservation and management inter alia as essential to reducing carbon release.

Keywords: Carbon Dioxide Emission, Gross Domestic Product, Energy Use, Autoregressive Distributed Lag Model, EKC Hypothesis, Kenya

INTRODUCTION

Ever since the times of agrarian and industrial revolutions, countries round the planet are battling to attain advanced economic development at the expenses of exploiting the current and predominantly the non-renewable natural resources. The pursuit has led to an increase in the release of Greenhouse Gases, mainly carbon dioxide (CO_2) which majorly contributes to global warming, ozone depletion and generally have harmful effects on the environment (Tiwari, 2011). The concentration of GHGs in the atmosphere can be measured in kilo tones (kt), metric tonnes (mt) or parts per million (ppm) (Tiwari, 2011). The profusion of GHGs in the space has been on the rise since 1750 (industrial revolution) as a result of anthropogenic activities from Carbon dioxide comparable of 280 – 450 ppm, opposite to projected margin of 350 ppm (Arouri *et al.*, 2012; Stern, 2013). Many scientists have indicated that elevated discharge of CO_2 is one of the primary significant triggers of global warming that results into climatic instability (IPCC, 1996; Kaygusuz, 2009). Throughout the twentieth century regular worldwide surface heat rose by 0.6°C, snow wrap and ice degree cut down by 10% and sea level increased by 10 to 20 cm. To further emphasize the gravity of cumulative damage to the environment, it has been projected that worldwide regular temperature will keep on increasing through the 21st century by an additional 1.0 -3.5°C (Tiwari, 2011).

It is notable that the release of CO_2 into the atmosphere originates from human activities basically geared towards meeting the needs of current generation but most often with a consequence of affecting the capability of the next generations to convene their own needs because high CO_2e causes weakening of the ozone and overall negative impact on the environment. Consequently, the non-reusable resources are rapidly being run down as a result of their elevated depletion motivated by human activities and inhabitant's expansion in the leading markets. As a matter of fact, it is projected that a single remnant fuel residual after 2042 will be coal (Raj & Singh, 2012). The increasing peril of worldwide temperature rise and climate alterations has therefore led to focused attention onto the macroeconomic variables and environmental pollutants. Worldwide emissions statistics offer vital information on collective progress, they cover the dynamics at the country level, and though discharge decrease are wanted worldwide, the pinnacle emitters are accountable for the majority transformation in the worldwide discharge (UNEP, 2018). China alone releases more than one quarter (27%) of global GHG emissions, the ups and downs of Chinese emissions leave an important track on global emissions growth. Some reports have taken a chance that Chinese emissions, more specifically coal consumption may have peaked (International Energy Agency, 2016). Figure 1 presents a summary global share of CO_2e in 2015.

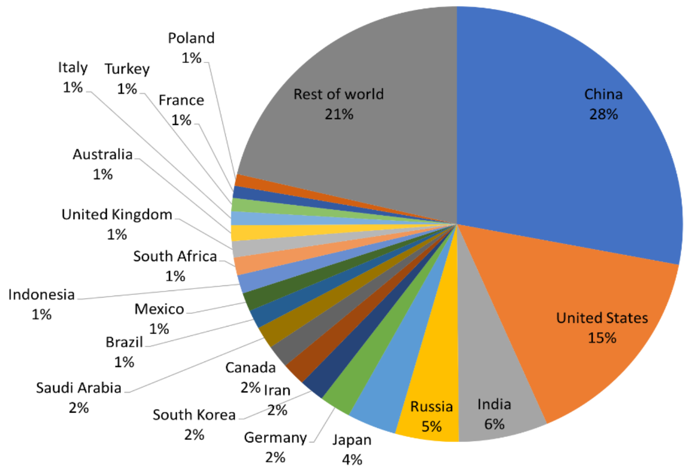

Figure 2: Stake of global carbon dioxide emissions from fuel combustion (2015).
Source: International Energy Agency (2016)

The image that materializes from the figure is one where developed countries and major developing economies are typically leading in total CO_2e while more or less developing countries lead in the growth rate of CO_2. Visibly, these jagged contributions to the climate problem are key to establishing effective and fair solution to addressing climate change challenges. This observation is supported by (Çetintaş & Sarikaya, 2015) who assert that; although up to currently, most manmade GHGs have been released by the manufacturing countries, the contribution of the developing countries have also rapidly enlarged now and future as well.

The Kenya Vision 2030 is visualized to give jobs and improve the quality of life to its citizens. This has led to the rise in energy demand and use due to increased energy demand for manufacturing, agriculture, ICT and transport sectors. This point to the Kenya's solid pursuit to transition her economy from agricultural to manufacturing and services sectors which are highly energy intensive.

A report by USAID (2017) explains that farming was the foremost origin of Green House Gases discharge in Kenya in 2013, providing 62.8% all release not including the Land Use Change and Forestry (LUCF). Farming contributes to 55% of emissions from fermentation from livestock and manure. It is followed by energy which contributes to 31.2% of the total emissions while fuel incineration and transportation contributes 74.3 percent of energy emissions. Industrial processes contribute to 4.6% and waste contributed to 1.4%.

USAID (2017) reports that activities in the LUCF sector to have removed 31.2% million Mt of CO_2 equal to ($MtCO_2$) in 2013, representing a substantial CO_2 sink. In comparison, Kenya's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC), which includes a Green House Gases record for the time of 1995-2010, shows LUCF to be a birthplace of discharge as oppose to sink. The Second National Communication indicated Land Use Change and Forestry activities released on average by 17.2 $MtCO_2$ equivalents per year from 1990 to 2010, which observed to be similar with the seen decreased forest cover in Kenya over similar period. Likewise, other authors have loss of forest cover in Kenya. In spite of the disparity LUCF findings, both the SNC inventory and USAID confirms the agricultural sector as the primary source of Green House Gases emissions in the Country, trailed by energy. Figure 2 presents a summary of Kenya's GHGs by region and proportion of overall discharge as at 2013.

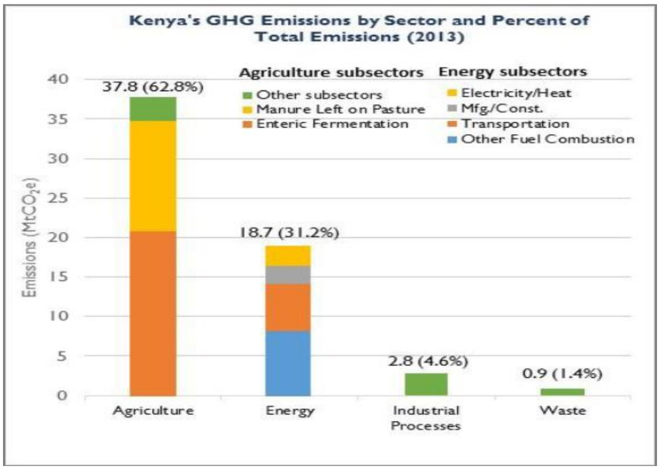

Figure 2: Kenya's GHG Emissions by Sector and % of Total Emission (2013).
(Note: percent of total emissions exclude LUCF)
Source: USAID (2017)

METHODOLOGY

Data

Time series data for the study variables spanning 1963 to 2017 was mined from the World Development Indicators (WDI) from the official website of the World Bank (WB) in excel format and combined homogeneously as per the variables for the period under review. Deliberate and conscious effort was made to make sure high level of credibility, trustworthiness, value, applicability, conformability and consistency of the data collected is achieved. The main importance of analysis of secondary data is because it is the cost effectiveness and ease it offers.

Diagnostic Tests for Time Series Properties

To improve the flow of the study, Table1 provides an impression of the diagnostic test procedures undertaken.

Table 1: Time series diagnostic tests performed

Diagnostic test	Test statistic
A. Normality	A. Jarque-Bera
B. Serial correlation	B. Breusch- Godfrey
C. Heteroscedasticity	C. Breusch-Pagan-Godfrey

Source: Research Data (2019)

Data Analysis

Data on the study variables was analysed using statistical software E-views 9. The recorded values for the variables were reviewed for completeness. Descriptive statistics was run to provide a general view on the distribution, trends and or changes on data sets over time for the period of analysis. This entailed showing trends of the variables in form of graphs. Inferential statistics were also applied to make inferences about regression parameters.

To achieve the study's main objective of establishing the connection between the selected macroeconomic variables and carbon dioxide emissions (CO_2e), the study estimated the ARDL bounds testing model for short run and long run relationship following the methodology proposed by (Pesaran, 2008).

Model Specification

Led by the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) equation as set out in (Halicioglu, 2009; Kohler, 2013), the functional representation was formulated as follows:

$$CO_{2t} = f(ENU_t, EMPA_t, INVA_t, GDPPC_t, TPOP_t,) \dots\dots\dots\dots\dots\dots (3.1)$$

The experimental specification for the model is quantified as:

$$LnCO_{2t} = \alpha_0 + \beta_1 LnENU_t + \beta_2 LnEMPA_t + \beta_3 LnINDVA_t + \beta_4 LnGDPPC_t + \beta_5 LnGDPPC_t^{\ 2} + \beta_6 LnTPOP_t + \mu_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.2)$$

Where:

$LnCO_{2t}$ – natural logarithm of CO_2 emissions in year t
$LnENU_t$ – natural logarithm of energy use in year t
$LnEMPA_t$ – natural logarithm employment in agricultural sector in year t
$LnINDVA_t$ – natural logarithm of industry value added in year t
$LnGDPPC_t$ – natural logarithm of GDP per capita in year t
$LnGDPPC_t^{\ 2}$ – natural logarithm of GDP per capita squared in year t
$LnTPOP_t$ – natural logarithm of total populationin year t
α_0 – intercept of the regression line

$\beta_1 - \beta_6 -$ regression coefficients to be estimated and
μ_t – stochastic error term
The subscript *t* refers to year *t*

The study employs the ARDL model to analyse the macroeconomics variables and CO_2e nexus and enlisting the quadratic form to asses for the cogency of EKC hypothesis for Kenya. Following the works of (Pesaran et al., 1999), the ARDL co-integrating equation is articulated as follows:

$$D(LnCO_2)_t = \alpha_0 + \beta_1(LnCO_2)_{t-1} + \beta_2 LnENU_{t-1} + \beta_3 LnEMPA_{t-1} + \beta_4 LnINDVA_{t-1} + \beta_5 LnGDPPC_{t-1} + \beta_6 LnGDPPC_{t-1}{}^2 + \beta_7 LnTPOP_{t-1} \sum_{i=1}^{n} \beta_8 . D(LnCO_2)_{t-i} + \sum_{i=1}^{n} \beta_9 . D(LnENU)_{t-i} + \sum_{i=1}^{n} \beta_{10} . D(LnEMPA)_{t-i} + \sum_{i=1}^{n} \beta_{11} . D(LnINDVA)_{t-i} + \sum_{i=1}^{n} \beta_{12} . D(LnGDPPC)_{t-i} + \sum_{i=1}^{n} \beta_{13} . D(LnGDPPC)_{t-i}{}^2 + \sum_{i=1}^{n} \beta_{14} . D(LnRPOP)_{t-i} + \mu_t \ldots\ldots (3.3)$$

Where the parameter α_0 is the drift component (intercept), $\mu_t$is the white noise error component (error term), $\beta_1 - \beta_7$ explain the long run coefficients, while $\beta_{8'} - \beta_{14}$ explains the short run constants of the equation and D is the 1st difference operator. The adoption of ARDL co-integration among variables makes it possible for estimation at either I(0) or I(1) without pre-specification of variables which are also I(0) or I(1). Additional, unlike Johansen's method of co-integration approach which uses a set of co-integration equations to analyse the long-run symmetry association among variables, the ARDL method of co-integration uses merely one equation. Furthermore, ARDL has enviable small sample properties and provide impartial long-run estimation, even when some endogenous variables behave as repressors.

The primary step of ARDL co-integration is the bounds testing process which is based on the F-test. The null hypothesis of no significant co-integration among the variables was expressed as
$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$
contrary to the alternative hypothesis
$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$
. The decision criteria is; there is a co-integration relationship amongst the variables, if the calculated F statistics is more than the upper critical bound (Pesaran, 2008). If the F statistics is lower than the lower critical bound, then the null hypothesis that there is no co-integration is accepted. The decision regarding co-integration would be indecisive when the F statistic lies within the upper and lower critical bounds in which case either the estimation of Johansen's test of co-integration or testing the steadiness of the co-integration space using CUSUM and CUSUM of squares of residuals is undertaken.

To assess the goodness of fit of the model, the model stability test Ramsey regression equation specification error test (RESET) technique was employed. The Akaike Information Criterion was used to automatically conclude the optimum lag at 2 and 3 for the dependent variable and independent variables, respectively. The EKC Hypothesis validity for Kenya was tested using the quadratic form of ARDL model.

RESULTS

This section offers the experimental findings of the study and their interpretation. An expressive statistical analysis of the variables is concisely examined, diagnostic test outcomes and ARDL estimation results analysis are presented.

Descriptive Statistics

Descriptive statistical study of the time series variables from 55 observations is presented in Table 2. Table 2 reveals none of the variables reflect normal skewness in their raw forms with values not equal to zero (0) signifying non-normal distribution around their respective means. Specifically, ENU and GDPPC have positive skewness indicating a long right tail, this suggests higher values than respective means. Further, the Jarque-Bera test statistic proposes that EMPA, ENU and GDPPC are not typically distributed at a 5% significance level. Hence, data was normalized by taking natural logs of the variables to offer a more stable data variance for the subsequent analysis.

Table 2: Descriptive statistics

	CO_2	EMPA	ENU	GDPPC	INDVA	TPOP
Mean	6434.12	52.99	453.60	5.08	16.87	25533596.00
Median	5192.47	55.93	453.10	4.66	16.91	23724579.00
Maximum	14286.63	61.06	513.43	22.17	19.38	50221473.00
Minimum	2401.89	43.90	430.52	0.23	13.56	8928511.00
Std. Dev.	3304.05	5.95	13.95	4.00	1.38	12451660.00
Skewness	0.74	-0.26	1.55	2.02	-0.26	0.39
Kurtosis	2.51	1.38	7.68	8.82	2.50	1.93
Jarque-Bera	5.64	6.67	72.30	114.97	1.19	4.03
Probability	0.06	0.04	0.00	0.00	0.55	0.13
Sum	353876.50	2914.20	24947.77	279.47	928.00	1.40E+09
Sum Sq. Dev.	5.90E+08	1912.15	10502.14	863.93	102.31	8.37E+15

Figure 3 shows the tendency of the study variables. The choice of study variables is based on the part they play in Kenya's environmental health. All the variables but TPOP show non-linear movement pattern. CO_2e and ENU, exhibits consistent increases and decreases periodically which suggest the existent of a strong relationship amongst them. CO_2e presents a fairly sustained increasing trend for the period under investigation. This provides the statistical evidence necessary to qualify the decision by the Kenya government to sign up as a party to the Kyoto protocol on climate change in the year 2005 committing to minimize greenhouse gasses emissions centred on the scientific consensus that global warming is happening and it is extremely likely that human made CO_2 have majorly caused it. Notwithstanding, a visual review of the descriptive results for variables presents considerable possibility in predicting the presence of a relationship among them and therefore a more critical analysis is required.

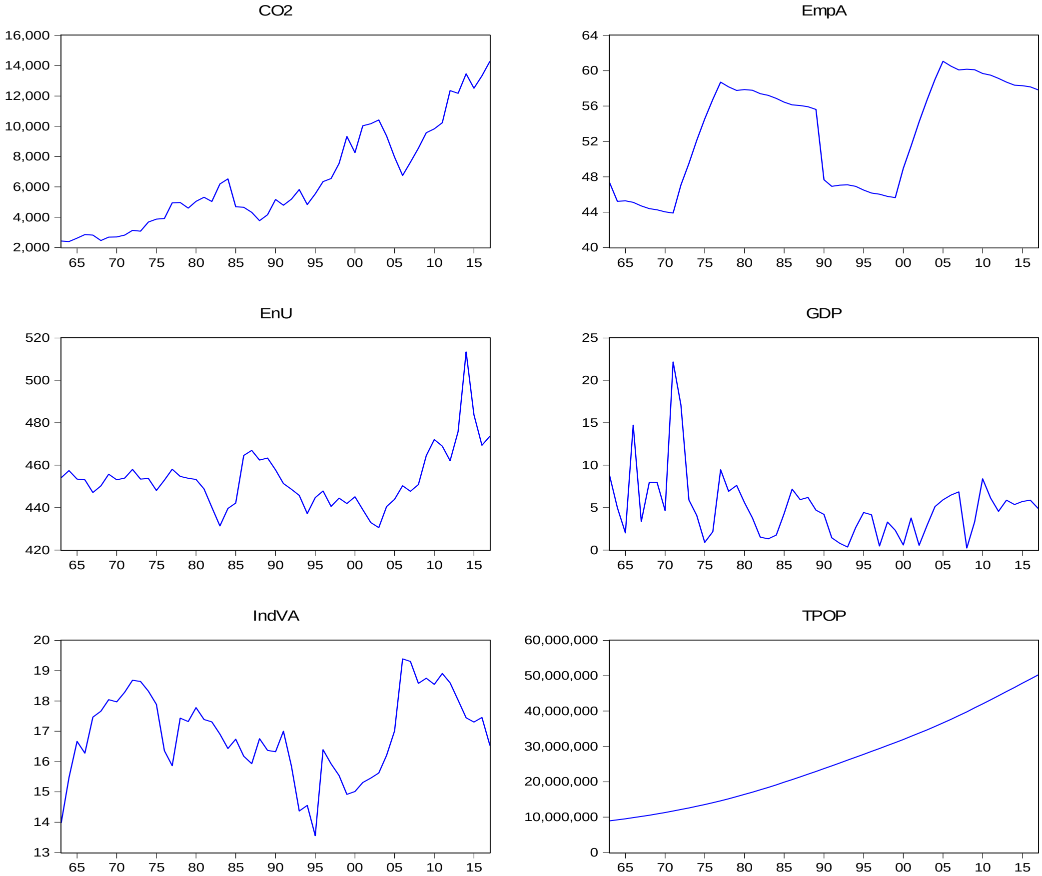

Figure 3: Trend of variables.

Stationarity Test

Data analysis commences with analysis for the stationarity properties of the expression. This is necessary to identify the order of integration presented by the variables to avoid false regression results. Following the process discussed by (Asteriou & Hall 2015) to have robust results, Augmented Dickey Fuller (ADF) unit root test technique was adopted. ADF unit root test was conducted at level and 1st difference; using intercept only, trend and intercept and without trend and intercept. Table 3 indicates that the variables are integrated of order I (0) and I (1) given the ρ - values.

Table 3: Augmented Dickey Fuller (ADF) Unit Root Test

Variable	Level (5%)					
	None		Intercept		With trend and intercept	
	Lag	ρ - value	Lag	ρ - value	Lag	ρ – value
CO_2e	6	0.9819	6	0.833	6	0.0774
EMPA	1	0.829	1	0.5889	1	0.3508
ENU	1	0.6763	0	0.0137	0	0.0554
GDP	7	0.3894	0	0.0002	0	0.001
GDP2	5	0.3019	5	0.3721	5	0.6961
INDVA	0	0.7866	0	0.0446	0	0.1774
TPOP	Dropped				5	0.998
	1st Difference (5%)					

	None		Intercept		With trend and intercept	
	Lag	ρ - value	Lag	ρ - value	Lag	ρ – value
CO_2e	5	0.0454	5	0.0712	5	0.2302
EMPA	0	0.0066	0	0.0648	0	0.2134
ENU	0	0.0000	0	0.0000	0	0.0000
GDP	6	0.0000	6	0.0000	7	0.0003
GDP2	4	0.0000	4	0.0000	4	0.0001
INDVA	0	0.0000	0	0.0000	0	0.0000
TPOP	4	0.1062	4	0.8871	4	0.1431

ARDL Model Estimation Results

Having performed the stationarity test and determined the variables are integrated of I (0) and I (1), the study set up ARDL bounds test to determine the presence of co-integration. Table 4 shows that the F – statistics is higher than the I (1) value, therefore the null hypothesis of no co-integration is rejected at 5% significance level. Therefore, the study proceeds to approximate the long run and short coefficients.

Table 4: ARDL Bounds Test

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	k
F-statistic	4.764448	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Table 5 presents the ARDL model for the short run and long run equilibrium relationship. Table 5 shows that the speed of adjustment $[CointEq\,(-1) = -0.45]$ is negative as projected and significant at 5% level, implying that a long run equilibrium relationship exists in succession from the exogenous variables of the study. The disequilibria in the years before of CO_2e are corrected to its current state at a 45% rate while there is a balance in GDP per capita, energy use, employment in agriculture, industrialization and population size.

The results in table 5 reveal that a part increase in employment in agriculture will reduce CO_2e by 1.5% in the short run and 3.4% in the long run at 5% significance level. This is contrary to reviewed literature where it was observed that agriculture is the top CO_2 emitter in Kenya. According to the World Bank data Agriculture accounts for 38% of total employment by sector, and contributes up to 62% of Kenya's total GHG emissions. The results further reveal that an increase in energy use will increase CO_2e by 7.1% in the long run. As discussed before, energy sector contributes up to 31% of Kenya's total GHG emissions. Kenya's energy demand is predominantly biomass energy at 70%. Biomass also forms 90% of the rural consumption needs. Further table 5 reveal that an increase in population will result to 1.8% increase in CO_2e. It is imperative to note that as population increase, the burden on energy, settlement and agricultural land increases which will often results into environmental damage if conservation efforts are not enforced. Ceteris paribus, EMPA, ENU, GDP, INDVA, and TPOP will minimize carbon dioxide emissions by 51% if conservation efforts are enforced which has policy implications.

Table 5: Short-run and Long-run ARDL

Co-integrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EMPA)	-1.526031	0.457330	-3.336828	0.0020
D(ENU)	0.511012	0.699197	0.730856	0.4696
D(GDP)	0.008970	0.022607	0.396775	0.6939
D(GDP2)	-0.004769	0.012800	-0.372611	0.7116
D(INDVA)	-0.319371	0.371257	-0.860240	0.3953
D(TPOP)	-125.579237	219.587259	-0.571888	0.5710
CointEq(-1)	-0.451671	0.102858	-4.391185	0.0001
Cointeq = CO2 - (-3.3786*EMPA + 7.1173*ENU + 0.0199*GDP -0.0689 *GDP2 -0.7071*INDVA + 1.8683*TPOP -50.7804)				
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EMPA	-3.378638	1.277415	-2.644902	0.0120
ENU	7.117333	2.200532	3.234369	0.0026
GDP	0.019859	0.049192	0.403711	0.6888
GDP2	-0.068915	0.035116	-1.962482	0.0575
INDVA	-0.707088	0.807105	-0.876079	0.3868
TPOP	1.868253	0.297238	6.285379	0.0000
C	-50.780375	13.845909	-3.667536	0.0008

The study also evaluates the legitimacy of the EKC in the ARDL model using the quadratic check by squaring the GDPPC. Results in table 5 discloses that both GDPPC and $GDPPC^2$ have positive and negative coefficients. This suggests an inverted U-shaped curve. The EKC was therefore empirically proven to be valid for Kenya.

The study also performed analytic and stability tests to examine the individuality of the residuals. Based on the diagnostic tests results summarized in table 6, the null hypothesis stated as; residuals are not normally distributed is rejected, the null hypothesis stated as; the residuals have no serial correlation can't be rejected and finally the null hypothesis stated as; errors have constant variance, that is; presence of homoscedasticity cannot be rejected, indicating presence of homoscedasticity. The results suggest the residuals are independent and therefore reliable for non-spurious regression results.

Table 6: The Results of Time Series Diagnostic Tests

Diagnostic test	Prob. (F-statistic)
A. Normality	$\rho = 0.48 > 0.05$
B. Serial correlation	$\rho = 0.49 > 0.05$
C. Heteroscedasticity	$\rho = 0.82 > 0.05$
A. Jarque-Bera	
B. Breusch-Godfrey	
C. Breusch-Pagan-Godfrey	

Ramsey regression equation specification error analysis (RESET) test was conducted to assess and establish the stability of the ARDL model adopted. The results revealed that the model was a strong fit with a strong forecast power signalling that predictors largely explained the variations in Co_2e. R squared was 97% while R squared was 96% indicating that the projected variables fit the definite data. Further, the long-run stability of the parameter estimates for the model was checked vide recursive estimations. The cumulative sum of (CUSUM) and the CUSUM square (CUSUMSQ) plots were found to range within the five percent significance level. The analytical and stability tests therefore indicate the residuals in the model have stable parameters and are independent to enable impartial statistical inferences.

DISCUSSION

The study wanted to scrutinize the macroeconomic variables and Co^2 emissions (CO_2e) nexus in Kenya. The equilibrium association of every indicator has a policy insinuation for Kenya in the long run. A percentage increase in energy use raises CO_2e by 7% in the long-run. This is partly signalled by the importation of crude oil which has since increased from 4.5million tons to 6million tons (Energypedia, 2017). The rising demand for fossil fuels to power the transport sector, industrial production and oil-fired power plants leads to accumulation of more CO_2 into the atmosphere leading to environmental pollution. Further, domestic energy consumption in Kenya is led by charcoal, fuelwood and kerosene for cooking and warming and lighting purposes especially in the rural areas due to increased poverty. The unsustainable and illegal techniques used in the acquirement of these biomass power sources have caused environmental related issues like desertification, pitiable air quality, loss of forest cover, food shortage, drought e.t.c making it challenging to sustainable environment (Energypedia, 2015). The long-run results revealed that an increase in employment in agriculture will decrease CO_2e by 3.4%. This result implies that embracing environmentally sustainable agricultural practices that improves household welfare will lead to a significant reduction in CO_2e. Therefore, a low carbon agricultural economy is the best strategic choice to adopt for increased productivity. The long-run results also indicated that GDP per capita rises CO_2e by 0.02%, nevertheless, the square of GDP per capita negates CO_2e by 0.07% affirming the validity of EKC hypothesis. This result is consistent to research by (Asumadu-Sarkodie & Owusu, 2016), however, it is in contradiction to a study by (Al-Mulali *et al*., 2016) that EKC hypothesis does not occur in the country in the case of contamination of air. The inverted U shaped result has policy implications – as the fortunes of the country improves, environmental contamination seems to rise over time nevertheless, as revenue level hits equilibrium, environmental contamination starts to decrease as revenue level increases in Kenya. A percentage rise in total population increases CO_2e by 2%. As population increases, the burden on energy demand, settlement and agricultural land increases, therefore if conservation efforts are not enforced, these will result into environmental damage.

CONCLUSION

The study sought to evaluate the underlying connection amid the macroeconomic variables identified as; employment in agriculture, Gross Domestic Product per capita, economic development, power use and overall population with CO_2e, an indication from Kenya by using a time series data straddling from 1963 to 2017 using the ARDL model to approximate the short-run and the long-run coefficients. The study also made an attempt to check the legitimacy of EKC in Kenya. The ARDL model confirmed an inverted U shape endorsing the validity of EKC hypothesis for Kenya. The model also revealed 45% speed of amendment of the disturbances from the year before in CO_2e to balance in the present year as a result of equilibrium in power use, employment in agriculture, GDP per capita, industrialisation and total population. The study also revealed that a rise in energy consumption pushes CO_2e to increase by 7% in the long-run. This is explained by the ever-increasing levels of demand for petroleum products. The rising demand for fuel for motorised transport and fuel for industrial production and oil-fired power propels this increase. Further, domestic energy consumption in Kenya is also led by charcoal, fuelwood and kerosene for food preparation and warming and lighting purposes due to increased poverty. Thus, knowledge formation and monetary grants that promote the procurement of enhanced energy stoves is advisable. The study further showed that a unit increase in employment in agriculture reduces CO_2e by 3.4%. This result implies that a low carbon agricultural economy is the best strategic choice to adopt for increased productivity. Ceteris paribus, when there is a rise in CO_2e, the joint consequence of energy use, employment in agriculture, GDP per capita, industrialisation and total population will decrease carbon dioxide emissions by 51%. This is possible if conservation efforts are enforced causing CO_2e to collapse back to its equilibrium state through sustainable technologies for example carbon confine and storage in the mining of oil and coal, reduction of clean and reusable power for local and commercial use, adopting green initiatives in building and construction, sustainable agriculture that focuses on productivity inter alia are essential to reducing pollution. As a policy inference, engaging the public through civic education on environmental management options will help address CO_2 emission challenges.

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