Original Research Article

Renewable Energy Consumption and Economic Growth in Uganda

This paper concerns itself with the relationship of renewable energy consumption on economic growth in Uganda using data of 1988-2018. Uganda is gifted with renewable energy resources and should be exploring the possibility of meeting the Sustainable Development Goal 7.

This paper uses vector error correction model, the augmented Dickey Fuller test for stationarity while for cointegration the Johansen test were used. The Granger test was used to test for causality between the variables of interest.

The findings indicate a negative relationship between renewable energy and economic growth. While a positive relationship exist between Gross Domestic Product and gross capita formation, electricity trade, carbon dioxide emissions and Trade Openness that are taken as controls of this model.

In conclusion therefore, Uganda need to pursue clean energy policies, while expanding its electricity trade in the East African community in order to absorb the excess electricity supply over peak domestic consumption. This paper will also increase the understanding on the need to integrate energy markets with in the region for greater benefits.

*Keywords: (*Energy consumption, Renewable energy, Economic growth, Uganda*)*

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1. INTRODUCTION

Energy is a vital determinant of economic growth. It stimulates investment, income and employment through the multiplier effect [1]. Following a steady rise in the global consumption of crude oil and rising emission of greenhouse gases (GHGs) with its attendant challenges. There is an unprecedented effort to step up the consumption of renewable energy and promote sustainable growth and development [2]. Although studies on renewable energy consumption and economic growth have been done [3], [4], [5], [6], [7] none of those was carried out in Uganda. Related studies carried out for the case of Uganda are associated with Electricity consumption and Economic growth in Uganda [8], [9], [10], [11], [12]. The renewable energy question was still left unanswered. This study therefore seeks to unveil the peculiar relationship between renewable energy consumption and economic growth for the case of Uganda and how this interplay promotes decision making regarding sustainable growth and development.

This enquiry seeks to investigate the direction of causality of renewable energy on economic growth in Uganda; with a view of informing policy. With Uganda's renewable energy (RE) arising from traditional biomass and renewable electricity, it is not clear how this consumption mix impacts on economic growth. Traditional biomass refers to inefficient use of fuel wood, charcoal, tree leaves, and agricultural residues for cooking, lighting and space heating [13]. This perpetrates indoor air pollution (IAP) leading to adverse health concerns such as respiratory tract diseases, and other chronic pulmonary diseases [14], [15]. However, modern biomass has the potential of providing clean and efficient energy in the future in Uganda as it is in developed countries [16], [17].

Large foreign investments into renewable energy infrastructure, generation and consumption has been done with a view that this will promote rapid economic growth [18]. The large foreign investments into renewable energy leads to increased public debt, so its impact on economic growth in Uganda is not clearly known. The complexity of the energy system in Uganda and how renewable energy resources are extracted and developed warrants this study [19]. Therefore, the increased interest of multinational corporations to invest in Uganda's renewable energy sub sector and how this promotes economic growth is a subject of investigation of this paper.

This study is motivated by the possibility of 100% RE mix, the need to achieve sustained growth and development that heavily relies on clean energy [20]. The need to transition from traditional biomass to renewable energy sources while maximising growth. This should rely on quality decision making that puts into account the dynamic causal relationship between RE and economic growth for which this paper investigates.

The main aim of this study is to investigate the relationship between renewable and non-renewable energy and economic growth, while specific objectives include to:

(i) Analyse the trend of RE consumption and economic growth in Uganda

(ii) Investigate the relationship between RE consumption and economic growth in Uganda

(iii) To investigate how existing RE policy influences economic growth in Uganda.

Uganda's current energy matrix is 89% from renewable sources. From all electricity sources, 92% is from renewable energy sources. 68% is from large hydro, 12 from small hydro power projects, 8% from bagasse co-generational while 4% is from solar PV [20]. Efforts to increase hydro power include the 600MW Karuma dam construction, which is 97% complete. Relying of hydro power with over 80% of the electricity mix presents a risk in case of fluctuations in the water levels of L. Victoria and consequently R. Nile as was the case in 2006. There is therefore need to diversify to other renewable energy sources for sustained economic growth. The renewable energy policy of 2007 was crafted to increase electricity access from 4 in 2006 to 42 % by 2020 using renewable energy resources. The biomass dominates this mix with 87% of overall energy mix. Most of the residential cooking energy is got from fuel wood and charcoal.

Uganda's renewable energy potential is mainly Hydro (4500MW), biomass (2500MW), solar (5000MW), wind and geothermal (1500 MW) constitute 33% of the overall energy mix. Yet the consumption mix is 87% this shows a fair consideration of renewable energy. But little information exists on how RE drives growth amidst plenty of energy resources yet nuclear and thermal energy constitute 57% and 10% respectively. It is important that rational decisions are made based on existing information to yield the greatest outcome for sustainable growth and development.

The contribution of this paper is to use a multivariate framework of analysis with capital, real electricity trade and trade openness as controls to avoid an omitted variables bias, that many bivariate models are riddled with [21].

Secondly, we used a more robust methodology of vector error correction model, were a long run relationship existed among variables with Johansen. Granger causality procedure is used to

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analyse a dynamic causal relation among variables, with an intention to make a contribution to the theory of methodology [22].

Thirdly is contribution to empirical literature on the dynamic relationship between RE and economic growth as a developing country perspective. No country study has been undertaken to the best of our knowledge. It is this knowledge gap that this study seeks to fill.

Finally, the practical contribution to policy makers in appreciating and implementing an appropriate policy for REC, which will remove the country from a lacuna such that it improves rather than worsen the pre-existing situation. If it is energy portfolio diversification against efficiency goals then it must follow a rigorous and well-argued debate.

The remainder of this papers composed of empirical framework in section 2 with research hypothesis, literature on Renewable energy consumption and economic growth. Data, materials and methods in section three, Empirical analysis in section 4, conclusions and policy implications in section 5.

2.0 Empirical framework

Literature to appreciate the role of energy consumption on economic growth [23], [24],[25], while others demonstrate that overutilization environmental resource reduces the role of energy consumption on economic growth exist [27]. When the economy is growing energy consumption will shift to less energy intensive activities like from industry to service where energy consumption lowers economic growth [3]. The more the debate is analysed, the more controversial it gets; what seems to be emerging with consensus is that renewable energy sources generally emit less GHGs than non-renewable energy resources therefore causing les environmental degradation. The debate on REC and Economic growth is a highly contested debate. With conflicting results, a need to make more and deeper inquiries at country and cross country studies is timely in order to come up with unified views and logical explanations on causality between these two variables of study. The debate is far from over and with increased adoration of REC as a futuristic energy option then this debate needs to be treated as both important and urgent. With important lessons not only for Uganda, but many countries of Sub Saharan Africa (SSA).

Research hypotheses exist to link the relationship between REC and economic growth namely: the growth, conservation, the feedback and neutral hypothesis [27], [28].

(i) Growth hypothesis supports the argument that consuming renewable energy complemented with some non-renewable energy will promote economic growth. So the dynamic relationship runs from Energy to economic growth as supported by; [22], [29], [30], [31], [32],[33]. The growth hypothesis alludes to the fact that, it is renewable energy consumption that causes economic growth, thus, RE has both a direct and indirect effect on economic growth [28],[34],[35],[36],[37],[38]. For instance, renewable energy development like solar, wind, hydropower and biomass is a prerequisite for green and sustainable growth. The development of renewable energy facilities create employment opportunity in both the public and private sectors, ultimately increasing incomes to people hence augmenting economic growth. The direct channel is through investment in human and physical capital as it augments these inputs, there is an overall increase in output hence economic growth while

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indirectly through employment a key macroeconomic variable that is a precursor to economic growth [9].

(ii) Feedback hypothesis has a two way causal relationship between energy (Renewable energy and economic growth) [39], [40], [41]. The bidirectional hypothesis suggests complementarity between renewable energy consumption and economic growth. In other words, renewable energy drives economic growth just as economic growth can drive renewable energy consumption. And policies to increase renewable energy consumption should be consciously done to avoid any feedback loops that are injurious to the overall economy.

(iii) Conservation hypothesis has a unidirectional relationship running from economic growth to either renewable energy [42], [43], [44], [45]. And policies to increase renewable energy consumption may be undertaken to promote sustainable development. This hypothesis allows for adoption of energy efficiency without adversely affecting economic growth.

(iv) Neutral hypothesis shows that neither of the variables cause each other. The relationship between Renewable energy consumption and economic growth has such a tiny association with each other that in fact no causality exists [46], [47]. And policies to increase renewable energy consumption may have no direct causal link to this transmission mechanism as growth is majorly from other causes other than energy.

Literature on Renewable energy and Economic growth

To foster greener economic growth for sustainable developmental goals, investigating the link between renewable energy and economic growth becomes crucial in contemporary literature. Despite the interest in this area, empirical evidence has produced conflicting results, the debate is still inconclusive [48]. Furthermore, country studies [49] [50], [51], [54] that employs the time series methods of analysis. [53] found a bidirectional hypothesis. [22] investigated a causality relationship between renewable energy and economic growth for china using VECM and Johansen cointegration, they found a bidirectional relationship. [55], found a unidirectional relationship running from energy consumption to GDP, [56] found no causality, [30], investigated renewable, non-renewable energy and economic in Iran using data of 1979-2014 and found a unidirectional relationship running from renewable energy to Economic growth. [57] found a bidirectional relationship. [58] found a relationship running from renewable energy consumption to GDP. [59], found a relationship running from RE consumption to GDP. [60] found a unidirectional relationship running from RE consumption to GDP, while study of [61] found no relationship between the variables.[62] found the relationship running from energy consumption to GDP. [63] found no relationship between electricity and GDP of Denmark. [64] studied Nepal and found no relationship, earlier [66] had studied the same and found a unidirectional relationship running from electricity to economic growth. [65] studied 28 EU countries using data of 1995-2015, VECM methodology and Dumistrescu- Hurlin confirmed a growth relationship between renewable energy and economic growth. [67] found a bidirectional relationship. [69] found a unidirectional relationship running from renewable energy consumption to GDP. [70] found a unidirectional relationship running form RE consumption to economic growth, which is in agreement with earlier work of [71]Agee and Butt (2015). [68] found a relationship running from GDP to RE, while Junsheg et al. (2018) using Toda Yamamoto and Granger found the relationship running from RE consumption to GDP. The

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findings are contentious and this debate is not yet concluded, no country studies of this kind have been carried out in Uganda, this study therefore, seeks to establish the relationship of REC on economic growth to be able to guide decision making.

3.0 Data, Materials and Methods

The study will use expost facto research design, with a quantitative approach [72]. It uses logical positivistic, antirealist instrumentalism [73] to advance the debate. Tokens of the observable world are captured in the time series data that is availed to this study for analysis. This will enable the use of time series secondary data to investigate the relationship between dependent (Economic growth) and independent variable (RE). This covered a period of 31 years from 1988-2018. All the data from the selected variables are continuous in nature. This is supported by [74] who highlighted that time series research is frequently quantitative in nature. Time series analysis is used to describe patterns of change in individuals or other units of measurement over time; establish the direction and magnitude of relationships among conditions, events, treatments, and later outcomes as measured by parameters of independent variable. In this study the dependent variable is GDP, while the independent variables are renewable, CO2, Gross fixed capital formation (GCF), real electricity trade (ELT), trade openness (OPN).

Annual data of Uganda's GDP, REC, and Gross fixed capital formation (GCF) from1988 to 2018 was obtained World Bank Development indicators. The variables selected included; Gross domestic Product, Gross Capital formation both at a constant. US$ 2010, Renewable energy consumption.

Table 1: Variable description and expected signs

Variables	Symbol	Measure	Expected Sign	Data source
Gross Domestic Product	GDP_t	GDP constant 2010 US$	+	World Bank: World development indicators(WDI)
Gross capital formation	GCF_t	GDP constant 2010 US$	+	World Bank: World development indicators (WDI)
Carbon dioxide	$CO2_t$	Per capital CO2 emissions	+	World Bank: World development indicators (WDI).
Trade Openness	OPNt	$(\text{Export} + \text{Import})/G$	+	World Bank: World development indicators (WDI).
Real Electricity trade	ELT_t	(Electricity Exports +Imports)	+	World Bank: World development indicators(WDI)
Renewable energy	REC_t	GWh	+	International Energy Agency (IEA)

The choice of Constant GDP is used to measure economic growth is preferred since it takes care of inflationary tendencies over time, while gross capital is used as a key input in the aggregate production function, trade openness, Electricity trade are controls in the conventional Solow

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model. Trade openness is a ratio of the sum of exports and imports to GDP. Real electricity trade (ELT) is constructed as the sum of net electricity imports and exports as a proxy for energy trade in the region. These controls are chosen because they significantly influence RE investments and uptake.

To analyse the relationship between REC and economic growth, the study uses a multivariate framework, this is preferred because it overcomes the omitted variables bias [75], based on the neoclassical production model where gross capital formation (GCF), and energy are taken as separate inputs. This helps avoid the omitted variables bias. The model specification is given as

Y_t= f (K_t, L_t, $REC_{t,}$, ELTt, OPNt, CO2t)…………………………………………… (1)

Where Y is real GDP, K is capital stock, L is labour, REC is renewable energy, OPN is trade openness, CO2 is carbon dioxide emissions.

Theoretical model- The neo classical aggregate production framework

The neo classical aggregate production model was used to analyse the relationship for REC and economic growth. The standard aggregate production follows a growth model advanced by Solow growth (1956, 1987), was adapted. We take the translog as shown below:

$LGDP_t = \beta_0 + \beta_1 LGCF_t + \beta_2 OPN_t + \beta_3 LREC_{t+} \beta_4 CO2_t$ ……..(2)

Where LGDP, LGCF, LLF, LREC, represent natural logs of Real GDP. Capital formation, Renewable energy consumption, real electricity trade (ELT),Trade openness (OPN) .

The VECM model is specified as the appropriate econometric model. Economic growth (Y) is modelled as a function of renewable energy function (RE), capital K), trade openness (OPN), Carbon dioxide emissions; which can then be transformed and rewritten by specifying an error-correction representative inclusive vector autoregressive model as follows;

$$(1-\delta)\begin{bmatrix} Log\ Y_t \\ Log\ RE_t \end{bmatrix} = \begin{pmatrix} \alpha_1 & \gamma 1 \\ \alpha_2 & \gamma 2 \end{pmatrix}\begin{pmatrix} I \\ X_{t-i} \end{pmatrix} + \sum_{i=1}^{p}(1-\delta)\begin{bmatrix} \beta 11 & \beta 12 & \beta 13 & \beta 14 \\ \beta 21 & \beta 22 & \beta 23 & \beta 24 \end{bmatrix}\begin{bmatrix} logK \\ logOPN \\ logCO2 \\ logELT \end{bmatrix} + \begin{pmatrix} V_{1t} \\ V_{2t} \end{pmatrix} \text{....(3)}$$

Note that all the variables are expressed in logs.

X = the Error-Correction Model (ECM), which is the lagged value of the error term from the following cointegration equation below:

$$Y=\alpha_0+\gamma E_t+\beta_1 K_t+\beta_2 RE+ \beta_3 OPN_t+\beta_4 ELT+ \beta_5 CO2e_t \text{…………………………..(4)}$$

$$(1-\delta)Y_t = \alpha_0+X_{t-1}+Y_{t-1}+V_{1t} \text{…….………..(5)}$$

$$(1-\delta)Y_t = \alpha_0 + X_{t-1} + \sum_{i=1}^{m}(1-\delta)Y_{t-1} + E_{t-j} + V_{1t} \text{………………………………………………………….(6)}$$

$$(1-\delta)Y_t=\alpha_0+X_{t-1}+\sum_{i=1}^{m}(1-\delta)Y_{t-1}+\sum_{j=1}^{n}(1-\delta)E_{t-j}+ V_{3t} \text{…………………………………….(7)}$$

$$(1-\delta)Y_t=\alpha_0+X_{t-1}+\sum_{i=1}^{m}(1-\delta)Y_{t-1}+\sum_{j=1}^{n}(1-\delta)E_{t-j}+\sum_{p=1}^{p}(1-\delta)E_{t-p}+V_{3t} \text{…………..(8)}$$

While applying vector error-correction modelling, we follow Miller (1991) by using different variables as the dependent variable and choosing the conditioning (left-hand-side) variable with the highest adjusted R-square. Further, in testing for causality between electricity consumption

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and economic growth, we used a Granger causality test. We proceeded to estimate this long-run relationship in a vector error correction framework. The normalised cointegrating relationship was between GDP and electricity consumption. These statistics are based on averages of the individual autoregressive coefficients associated with the unit root tests. All tests are distributed asymptotically as standard normal. The results indicate that there is a long-run equilibrium relationship between real GDP and electricity consumption, real gross fixed capital formation, and the labour force. Coefficients for real fixed gross capital, and labour force are positive and statistically significant at the 5% significance level, and given the variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity estimates.

$$\Delta Y_t=\omega_1+\sum_{k=1}^{q}\theta_{11k}\Delta Y_{t-k}+\sum_{k}^{q}\theta_{12k}\Delta RE_{t-k}+\sum_{k}^{q}\theta_{13k}\Delta K_{t-k}+\sum_{k}^{q}\theta_{14k}\Delta OPN_{t-k}+\sum_{k}^{q}\theta_{15k}\Delta ELT_{t-k}+\sum_{k}^{q}\theta_{16k}\Delta CO2_{t-k}\,\lambda_1\varepsilon_{t-1}+u_{1t\ldots}\ \text{(9a)}$$

$$\Delta E_t=\omega_2+\sum_{k=1}^{q}\theta_{21k}\Delta Y_{t-k}+\sum_{k=1}^{q}\theta_{22}k\Delta RE_{t-k}+\sum_{k}^{q}\theta_{23k}\Delta K_{t-k}+\sum_{k}^{q}\theta_{24k}\Delta OPN_{t-k}+\sum_{k}^{q}\theta_{25k}\Delta ELT_{t-k}+\sum_{k}^{q}\theta_{26k}\Delta CO2_{t-k}+\lambda_2\varepsilon_{t-1}+u_{2t\ldots}\ \text{(9b)}$$

$$\Delta K_t=\omega_3+\sum_{k=1}^{q}\theta_{31k}\Delta Y_{t-k}+\sum_{k=1}^{q}\theta_{32}k\theta_{22k}\Delta RE_{t-k}+\sum_{k}^{q}\theta_{33k}\Delta K_{t-k}+\sum_{k}^{q}\theta_{34k}\Delta OPN_{t-k}+\lambda_2\varepsilon_{t-1}+\sum_{k}^{q}\theta_{35k}\Delta ELT_{t-k+}\ \sum_{k}^{q}\theta_{36k}\Delta CO2_{t-k}+u_{3t..}\ \text{(9c)}$$

$$\Delta L_t=\omega_4+\sum_{k=1}^{q}\theta_{41k}\Delta Y_{t-k}+\sum_{k=1}^{q}\theta_{42}k\Delta RE_{t-k}+\sum_{k}^{q}\theta_{43k}\Delta K_{t-k}+\sum_{k}^{q}\theta_{44k}\Delta OPN_{t-k}+\sum_{k}^{q}\theta_{44k}\Delta CO2_{t-k}\,\lambda+_4\varepsilon_{t-1}+u_{4t..}\ \text{(9d)}$$

where Δ is the first-difference operator, q is the lag length set at one based on likelihood ratio tests, and u is the serially uncorrelated error term.

According to the Augmented Dickey Fuller (ADF) are used to test for stationarity. To test for unit roots in our variables, we use the Augmented Dickey Fuller (ADF) test. Using the results of Dickey and Fuller (1979), the null hypothesis that the variable shows that all variables.

Autocorrelation is the correlation of a time series with its own past and future values. We used the Breusch-Godfrey LM test for both AR(p) and MA (q) error structures as well as for the presence of lagged regressand and explanatory variables. The null hypothesis (Ho) is that there is no serial correlation of any order. If the sample size is large enough, Breusch and Godfrey have shown that:

$$(n-p)R^2 \sim X_p^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

Implying that asymptotically, n-p times the R^2 follows the chi-square distribution with PDF. If in an application, (n-p) R^2 exceeds the critical chi-square value at a chosen level of significance, we reject the null hypothesis. Thus, the null hypothesis is rejected if p-value is less than 5%, in our case it is 0.00 so we reject the null hypothesis.

Determining the appropriate Lag Length for VECM, model

The need for the lags arises because values in the past affect today's values for a given variable. This is to say the variable in question is persistent. There are various methods to determine how many lags to use. The AIC was used to determine the appropriate lag length given the large sample size of 155 observations in the 31 series. The appropriate lag length is 4 as shown in table 2

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Table 2:Selection-order criteria

Sample: 1992 - 2018 Number of obs = 27

lag	LL	LR	df	p	FPE	AIC	HQIC
0	159.589	0.000	-11.451	-11.380	-11.211		
1	279.621	240.060	25	0.000	0.000	-18.490	-18.062
2	301.648	44.053	25	0.011	0.000	-18.270	-17.485
3	344.973	86.650	25	0.000	0.000	-19.628	-18.486
4	400.197	110.45*	25	0.000	3.0e-15*	-21.8664*	-20.368*

Endogenous: lgdp lopn lelt lrec lco2

Co-integration test is useful in establishing if there exists a long-run relationship between the study variables. Generally, a set of variables is said to be co-integrated if a linear combination of the individual series, which are I(d), is stationary. Intuitively, if xt ∼ I(d) and yt ∼ I(d), a regression is run, If the residuals, εt, are I(0), then Et and yt are co-integrated. We use Johansen's (1988) approach, which allows us to estimate and test for the presence of multiple co-integration relationships. The choice of lag length is made according to the AIC criterion. In conclusion there is one co-integration rank (long-run relationship). When determining lag structures of the data-generating processes (DGP), we applied the Augmented Dickey Fuller test on the least square residual to implement the Engel and Granger procedure.

We may have a model that is correctly specified, in terms of including the appropriate explanatory variables, yet commit functional form misspecification. In this case, the model does not properly account for the form of the relationship between dependent and observed explanatory variables. In this study, a general test for functional form misspecification is Ramsey's RESET (regression specification error test) which was applied.

The error term is found to homoscedastic using the Breush Pagan test this shows the stability of the parameters using residual diagnostics to minimize errors (or residuals). The error term is be independently and identically distributed (i.i.d). Using the correlogram, the error term of the estimated model. This procedure of log transformation is important because it stabilises the means, however the means are also non stationary.

The Jacque Bera normality test was used to test for normality, which variable is relevant to express as linear combination among other variables, using the maximum likelihood- auto regressive conditional heteroskedasticity (ML ARCH) the residuals were normally distributed shown in table 3.

Table 3: Jarque-Bera test

Equation	chi2	df	Prob>Chi2
D_lgdp	0.318	2	0.853

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D_lopn	1.099	2	0.577
D_lelt	0.653	2	0.721
D_lelc	0.417	2	0.812
D_lco2	0.702	2	0.704
ALL	3.189	10	0.977

For causality, the Granger Wald causality test was used, a negative causal relationship exists between RE and GDP.

4.0 Empirical Analysis

In order to identify the model and reduce on false regressions all variables in levels were transformed and the table 4

Table 4: Descriptive statistics

Description of variables

Name	Varlab
Year	YEAR
Gdp	GDP constant 2010 Billion US$
Rec	Electricity net consumption; Billion kWh
Elt	Total Electricity trade Billion kWh
opn	Trade openness
co2	CO2 emissions; kiloton
Gcf	GCF; constant 2010 Billion US$

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Lgdp	31	1.208	.257	.787	1.601
Lopn	31	-.516	.101	-.721	-.367
Lelt	31	-.838	.156	-1.046	-.444
Lrec	31	.64	.212	.217	1.041
lco2	31	3.287	.313	2.863	3.787
Lgcf	31	4.675	3.004	1.42	10.72

Unit root analysis

In order to examine the impact of renewable and non-renewable energy consumption on economic growth, unit root tests are tests conducted to establish the stationarity of the variables. Augmented Dickey Fuller and Phillips Perron tests are some of the tests performed.

From the results renewable energy consumption has an inverse relationship with economic growth implying the conservation hypothesis. This means that Uganda can safely pursue its clean energy goals to achieve sustainable development. It can also improve its energy efficiency as it diversifies its renewable energy mix.

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Greater investment must be undertaken in clean energy generation and consumption as has positive multiplier effects and can drive industrial and commercial output hence economic growth [76].

However, GDP is positively associated with gross capital formation, Electricity trade as well as trade openness. This can therefore promote greater integration of energy markets within the East African Market.

5.0 Conclusions and policy implications

The study examined a quantitative analysis of renewable energy consumption and Economic growth in Uganda between 1988- 2018. No country study has been carried out for Uganda, this is a novel in revealing country specific information and the appropriate policy direction. Using the unit root, co-integration, empirical results were analysed. Estimation results shows co-integration exists among all variables, therefore a long run equilibrium exists. REC is negatively affecting GDP. This means Uganda should invest more in modern RE as the dominating traditional biomass is inversely related to economic growth, it is not sustainable to continue along that paradigm. It is possible to invest in modern bioenergy technologies that are friendly to the environment and would avoid carbon dioxide emission. This conservation mechanism has been supported by other studies [1], [77]

Uganda continued use of traditional biomass is not sustainable, since it can substitute this with cleaner energy options; then it should diverse its clean energy goals mainly by stepping up the production of more Solar, biomass, geothermal and hydroelectricity as well as nuclear energy potential. This will help increase output in both the industrial and commercial sector [9]. As with a diverse power base electricity efficiently serves industry and commercial sector as other intermittent power source feed the residential and transport sector.

Increased marketization of electricity into the East African Community, because Uganda has an excess electricity supply capacity. With a reserve capacity of 40 % yet elsewhere in the region remarkable electricity shortages occur.

Uganda ought to systematically reorganise its energy sector by keeping up to date information (EIB Report 2018). An electrification master plan ought to be developed informed by research and sound policy. The clean energy policy must be crafted clearly giving a clear road map on how these energy sources are to be developed.

There should be increased marketization of electricity with the region so that there is increased supply capacity for Uganda can be traded to neighbouring countries with acute electricity shortages at the ongoing market prices. This will foster greater cooperation within the East African Community [78].

The renewable energy policy is in dire need of a review to carefully capture clear and meaningful guidelines on a diversified energy portfolio in the renewable energy systems and sustainability. There is need for independent policies on geothermal, solar, wind, which would ensure investor confidence and proper exploration and development of these energy sources. Renewable energy consumption should be deepened from the low grade and low intensity tradition biomass is dominant and cannot drive industrial growth so a need to promote modern bioenergy and energy saving mechanism as a way to promote sustainable growth and development.

For further interrogation economic growth should be interrogated further with carbon emissions to establish whether energy investment is helping save carbon emissions. It is possible that these

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multinationals are targeting Uganda for having less strict regulations on pollution and environmental standards control [5]

The other area for further inquiry is to try and understand how regional energy markets work and this may include studying a panel of East African countries to establish whether with increased regionalisation energy markets have an increasing volume of trade [79].

Declaration

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Further we declare that no financial interests/personal relationships which may be considered as potential competing interests.

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