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Impact of Energy Use on the Agriculture Sector in Nigeria

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Abstract: *This study investigates the impact of energy use on the agriculture sector in Nigeria using time series data from the World Bank, International Energy Agency (IEA) and Organisation of Economic Cooperation and Development (OECD) National Data Accounts. The findings showed that fossil fuel energy use has a negative and significant effect on agriculture value added in both the short and long run. This finding indicates that the use of fossil fuels as an energy source has a negative implication on agricultural output and its share of the GDP. The results further showed that renewable energy use affected agriculture value-added positively in both the short and long run. The short-term positive effect of renewable energy use on agriculture value added is significant at the 5% level, indicating that the transition to renewable energy creates an opportunity for increased agriculture output growth. In addition, the results showed that alternative energy use has a positive and significant effect on the agriculture value added. The finding suggests that the share of agriculture output to GDP increases following an increase in access to alternative energy. The results further showed that total electricity use has no significant effect on agriculture value added in the short and long run. This finding could be attributed to the poor and unstable electricity supply, which undermines the intended and desired significant contribution of electricity utilisation to the agriculture sector in Nigeria. The error correction coefficient (-0.4826) is negative and significant at the 5% level, indicating that convergence to the long run equilibrium is achieved at the speed of 48.26%. Given the findings, this study recommends that policymakers should reduce fossil fuel dependency as a source of energy by diversifying energy sources to create more opportunities for firms in the real sector to boost their output and value addition to GDP.*
Keywords: energy use, agriculture sector, fossil fuels, renewable energy, electricity utilisation and Nigeria

INTRODUCTION

Energy use cuts across different dimensions, comprising solid biomass, animal products, biomass gases and liquids, and industrial and municipal waste. In developing countries, increased energy consumption is closely linked to growth in the real sector, leading to higher output in agriculture, manufacturing, and other industries. According to the United States

Energy Information Administration (2022), total energy consumption by end-use sectors includes their primary energy use, electricity sold and bought from the power sector, and energy losses within the electrical system. How energy is used varies depending on infrastructure and geographic location, affecting the amount, type, and methods of use. Because of its direct impact on global warming and climate change, energy consumption is highly relevant to geography.

Notably, the importance of energy cannot be overemphasised as one of the critical inputs in the agricultural production process. At the farm level, consumed energy consists of direct and indirect uses. On the one hand, direct energy use in agricultural activities includes crop production, poultry production, animal products production, and transportation of farm products. On the other hand, indirect energy is used off the farm for manufacturing and transportation of fertilizers and pesticides. According to the Food and Agriculture Organisation (FAO, 2021), agriculture uses energy both directly through machinery used to produce crops and livestock and indirectly through the use of pesticides and fertilisers. Ozigbu, Ezekwe and Morris (2025) assert that Nigeria's huge dependence on fossil fuels poses a threat to environmental sustainability.

Furthermore, Zhou et al. (2023) further explained that direct energy use includes energy that is directly used in a variety of agricultural operations, such as operating machinery and tools for various farm tasks, vehicles, and drying and refrigeration equipment. Esengun et al., (2007) contend that the amount of energy used in agriculture production varies greatly depending on the type of activity, the production techniques used, the location of the production region, and environmental factors including soil and climate. Similar to other sectors, the agriculture sector has become increasingly dependent on energy. Energy use in agriculture production rises as a result of the modernization of various processes (Bekhet and Abdullah, (2010).

Despite the importance of reliable and adequate energy access, few studies document the relationship between energy use and economic performance. This is worrisome given that an increase in energy use not backed by improved economic performance points to energy inefficiency. While studies such as Chinedu, Daniel and Ezekwe (2019), Muazu, Yu and Liu (2023) and Bekun et al. (2023), among others, have analysed the energy-growth nexus, there is scant evidence on the sector-specific contributions of energy use. Thus, a thorough and more specific investigation is required to deepen the understanding of the relationship between energy use and agriculture value added in Nigeria. In this light, we examine the impact of energy use on the agriculture sector growth, with specific attention to how various sources of energy, including fossil fuels and renewable energy, contribute to the agriculture GDP in Nigeria.

LITERATURE REVIEW

Theoretical Literature

This study is based on the energy-led growth hypothesis, which can be traced back to the pioneering work of Mason (1955) and Sims (1989). The theory assumes that investments and innovations in the energy sector can drive overall economic growth and development. It emphasises that by focusing on the energy industry through research, innovation, and infrastructure improvements, countries can not only stimulate growth within the energy sector but also create positive ripple effects across the entire economy, including manufacturing. By improving energy efficiency, adopting renewable energy sources, and committing to sustainable energy practices, countries can better meet their energy demands while creating new job opportunities, fostering technological advancements, and reducing environmental impacts.

Advocates of the energy-led growth theory, including Mason (1955) and Erol and Yu (1987), argue that prioritising energy development can lead to both economic prosperity and environmental sustainability over time. The theory is rooted in the belief that energy consumption is closely linked to economic growth, as energy is a key driver of economic activities. The growth hypothesis posits a one-way causality from energy use to economic growth. Abosedra, Shahbaz, and Sbia (2015) assert that energy is the lifeblood of the global economy, serving as a crucial input for producing nearly all goods and services in today's world. As a result, energy directly contributes to economic growth by creating jobs and value through the processes of extracting, transforming, and distributing energy. According to Barney & Franzi (2002), while energy constitutes less than 10% of production costs, it is responsible for driving at least half of the industrial growth in modern economies. Energy-led growth theory faces several criticisms. One major criticism is its limitation in accounting for the complex factors that contribute to economic growth. The theory tends to oversimplify the relationship between energy consumption and economic development, neglecting the multifaceted nature of growth processes. Additionally, critics argue that energy-led growth theory does not adequately consider the impact of technological advancements and innovation in shaping economic progress.

Empirical Literature

Zou (2022) analyzed the causal link between the growth in agricultural output value and total primary energy consumption for both the 1953 to 2020 and 1980 to 2020 periods. The main method applied is the Toda–Yamamoto Wald-$\chi 2$ test. Empirical results show that from 1953 to 2020, feedback existed between the growth in agricultural output and energy use. From 1980 to 2020, unidirectional Granger causality existed from energy consumption to the aggregate economy and agriculture. Thus, the study suggests the growth hypothesis in energy economics. In the short-run, agricultural growth will not increase energy consumption. However, strict energy-saving measures in the agricultural sector may curb its growth. During the period after 1980, agricultural energy use efficiency improved. Energy consumption was a short-run determinant of agricultural growth.

Chandio, Jiang, and Rehman (2019) empirically analysed how energy consumption relates to agricultural economic growth in Pakistan, covering the years from 1984 to 2016. They employed the autoregressive distributed lag (ARDL) bounds testing method to explore both the long-term and short-term factors influencing agricultural growth in the country. Their findings from the ARDL analysis indicate a significant long-term relationship among the variables studied. Specifically, the research highlights that agricultural economic growth benefits from both gas and electricity consumption, showing positive effects in both the long and short term. The coefficients for gas consumption and electricity consumption were found to be 0.906, 0.421, 0.595, and 0.276, respectively. Additionally, the estimated equation demonstrated stability throughout the 1984 to 2016 period, as confirmed by the stability tests. Using the Environmental Kuznets Curve (EKC) theory, Acuña-Ascencio, Carhuamaca-Coronel and Mougenot (2024) focused on establishing the relationship between the variables of energy consumption, GDP per capita, and mineral rents and their impact on the level of pollution by CO2 emissions in the period 1971–2019. The study used statistical and econometric tools based on the ARDL dynamic model through a time series analysis starting from historical data. Based on the findings, the study concluded that the variables CEpc, PBIpc, and RM have deleterious effects, as a 1% increase in these variables increases the level of environmental pollution.

Nazir et al. (2020) investigated the economic potential of the regions from the mining sector of North Morowali, Central-Sulawesi, Indonesia, and the formulation of pro-business regional development management that aims to create synergy between the local government and mining sector entrepreneurs. This study uses a descriptive qualitative approach by taking data in the form of primary data from FGD and secondary data observations from statistical bureau data in the North Morowali, Indonesia. The analysis unit uses SWOT analysis to determine the economic potential of the North Morowali and Location Quotient (LQ) to analyze the economic potential of the mining sector. The research period covers one year (2018-2019) in North Morowali, Indonesia. All the mining products have considerable potential as a financing unit in North Morowali, while mining potential has not been maximally exploited. The absence of regulations, facilities such as road access, and optimal land and sea transportation are the causes of the difficulty of optimization and access to explore mining products comprehensively.

Madzík *et al.* (2016) investigated the relationships between progress in the energy and mining industry and the competitiveness of selected countries. The focus of the study was determined by reviewing the expert literature on the topic, which showed that not many approaches appreciate the correlations between these two areas and pay closer attention to their historical relations. The study works with historical data on the energy and mining industry in selected countries and also data on the competitiveness of those countries. Correlations were examined using bivariate correlation analysis of respective time series. This research identified historically strong correlations, for instance, between electric power consumption, land area, or forest rent and indicators of national competitiveness. The results show that the influence of energy and mining industry on competitiveness over the last 40 years has increased, particularly in the case of countries with low or medium economic development, and it has decreased in developed countries. The resulting information about the intensity of the mutual relations might be useful for the management of competitiveness and planning of strategic economic tools.

Ariza, Vargas-Prieto and García-Estévez (2020) investigated the relationship between mining-energy and inclusive development indicators of local communities. The analysis includes several dimensions of inclusive development: education, health, security, and the quality of the local public management. The study focused two regions in Colombia which are the main mining-energy producers: Cesar, which produces more than 60% of the nation's coal, and Casanare, which produces 20% of the nation's oil. The study used a panel data estimation methodology based on the indicators for all municipalities from 2000 to 2015. The results show that mining-energy municipalities had, in general, better performance in social indicators than in other non-mining-energy municipalities.

METHODOLOGY

Model Specification

A multivariate model with the agriculture sector GDP as the dependent variable and energy use indicators as the independent variables was employed in this study. The model is specified in a functional form as:

AGV = f (FEU, REU, AEU, TOU) (1)

Where: AGV = agriculture sector value added, FEU = fossil fuel energy use, REU = renewable energy use, AEU = alternative energy use and TOU = total electricity use

Specifically, the autoregressive distributed lag (ARDL) model is specified below:

$$\Delta AGV_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta AGV_{t-1} + \sum_{i=1}^{q} \alpha_2 \Delta FEU_{t-1} + \sum_{i=1}^{q} \alpha_3 \Delta REU_{t-1} + \sum_{i=1}^{q} \alpha_4 \Delta AEU_{t-1} + \sum_{i=1}^{q} \alpha_5 \Delta TOU_{t-1} + \beta_1 AGV_{t-1} + \beta_2 FEU_{t-1} + \beta_3 REU_{t-1} + \beta_4 AEU_{t-1} + \beta_5 TOU_{t-1} + \varepsilon_t \quad (2)$$

Where: α_0 = constant parameter to be estimated, $\alpha_1 - \alpha_5$ = short-run parameters to be estimated, β_1 - β_5 = long-run multipliers, p = optimal lag operator for each of the dependent variables, q = optimal lag operator of the independent variables, Δ = first difference operator, ε_t = error terms

Data and Variable Description

The agriculture sector GDP valued added defines the net contribution of the agriculture sector to a country's GDP. It is calculated as the difference between the total output (gross production) of the agriculture sector and the intermediate inputs used in the production process. It was measured as a percentage of GDP. The energy use is measured by fossil fuel energy use, renewable energy use, alternative energy use, and total electricity use. Annual time series data were utilised in this study. Specifically, the data on service sector value added were obtained from the World Bank and the Central Bank of Nigeria Statistical Bulletin. Similarly, data on the energy use indicators were obtained from the World Bank, International Energy Agency (IEA) and Organisation of Economic Cooperation and Development (OECD) National Data Accounts. The datasets spanned from 1990 to 2023.

Data Analysis Techniques

In this study, we utilized the least squares method to estimate the ARDL models. It's important to note that the ARDL differs from the error correction mechanism (ECM), which is rooted in the work of Engel and Granger (1987). According to Hassler and Wolters (2006), the ARDL has gained traction in econometrics literature largely because it allows for the cointegration of nonstationary variables, which is akin to an error correction process. For the ARDL to be effectively estimated, the variables need to exhibit a structure of I(0), I(1), or a mix of both. This means that one of the first steps in working with the ARDL model is to determine the order of integration for each series using a unit root test. This step is crucial to ensure that none of the series are I(2), which would render the procedure invalid. Additionally, our data analysis included descriptive statistics, covering aspects like mean distribution, standard deviations, and the normal distribution of each variable throughout the study period. We also employed the augmented Dickey-Fuller (ADF) test, introduced by Dickey and Fuller (1981), for the unit root test, alongside the bounds cointegration test.

RESULTS AND DISCUSSION

Unit Root Test

The results of the ADF unit root test are presented in Table 1

Table 1: ADF Unit Root Test Result

Variable	ADF stat. at levels	ADF stat. at 1st diff.	Critical Value at 5%	Order of Integration
AGV	-1.9195	-6.4904***	-2.9604	I(1)
FEU	-2.7280	-5.8578***	-2.9604	I(1)
REU	-1.7160	-5.6900***	-2.9604	I(1)
AEU	-2.4903	-8.1275***	-2.9604	I(1)
TOU	-2.9633**	-	-2.9604	I(0)

Source: Computed from E-views Software

Note: *, ** and * denote Significant at 10%, 5% and 1% levels respectively**

The results show Total electricity use is stationary at levels given that the ADF statistics at levels is greater than the corresponding critical value at 5% level. Consequently, the null hypothesis of unit root is rejected at the 5% critical value. The implication of this result is that total electricity use is integrated of order zero I (0). On the other hand, the results show that agriculture sector value added, service sector value added, fossil fuel energy use, renewable energy use, and alternative energy use are non-stationary at levels, given that their ADF statistics at levels are less than the associated critical value at the 5% significance level. However, they were found to be stationary at first difference, indicating that they are integrated of order one (1).

Cointegration Test

The cointegration test results are reported in Table 2.

Table 2: Bounds cointegration test results

AGV FEU REU AEU TOU				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	3.929	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: E-views Software 12

The result shows that the computed f-statistic (3.929) is greater than the upper bound critical value (3.49) at the 5% significance level. Thus, this finding necessitates the rejection of the null hypothesis that no long-run relationship exists among the variables at the 5% significance level. Therefore, there is co-integration among agriculture value added and fossil fuel energy use, renewable energy use, Alternative energy use, total electricity use. This result agrees with the findings of some previous studies such as Usman, Anwar, Yaseen, Makhdum., Kousar, and Jahanger, (2022) and Jebli and Youssef, (2017) who reported evidence of a long run between energy use and agriculture sector growth.

Model Estimation

The least squares method was employed to estimate the ARDL models. The results are presented in Table 3.

Table 3: ARDL results for model

Dependent Variable: AGV				
Selected Model: ARDL(1, 2, 0, 0, 1)				
Short run results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FEU)	-1.92627***	0.670548	-2.872687	0.0086
D(REU)	1.01138**	0.481423	2.100823	0.0468
D(AEU)	52.7667***	15.600605	3.382355	0.0026
D(TOU)	0.060208	0.166647	0.361290	0.7212
CointEq(-1)	-0.4826***	0.139313	-3.464482	0.0021
Long run results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FEU	-4.57490**	1.990458	-2.298419	0.0310
REU	2.095496	1.275367	1.643054	0.1140
AEU	109.3278***	37.584964	2.908820	0.0079
TOU	-0.584504	0.369505	-1.581860	0.1273
C	278.386*	147.510085	1.887235	0.0718
Adjusted R-squared	0.582163		Prob(F-stat)	0.0000

Source: E-views Output (2025)

Note: *, ** and * denote significant at 1%, 5% and 10% levels respectively**

The findings showed that fossil fuel energy use has a negative and significant effect on agriculture value added in both the short and long run. This finding is contrary to the theoretical expectation which predicts that energy use contributes positively to agriculture sector growth. The negative effect of fossil fuel energy use on agriculture value added could be attributed to the increased pollution associated with fossil fuel which undermines the productive growth of the agriculture sector and its contribution to GDP. This finding is consistent with the findings of Ahmad, Safdar and Reza (2019), Tan *et al.* (2022) and Naseem, Guang-Ji and Kashif (2020) which highlight the adverse implications of fossil fuels on the agriculture sector.

In addition, the results showed that renewable energy use affected agriculture value-added positively in both the short and long run. This finding conforms to the theoretical expectations and highlights the benefits of renewable energy to agriculture sector development in Nigeria. This finding can be attributed to the clean and sustainable nature of renewable energy which has the potential to drive agriculture sector growth with little or no adverse negative implications. The significant positive contribution of renewable energy to agriculture value added is consistent with the findings of Liu, Wang, Rahman and Sriboonchitta (2021) and Qamruzzaman (2022), who reported that renewable energy source is significant in promoting the growth of agriculture.

The results further showed that alternative energy use has a positive and significant effect on the agricultural value added. The finding is consistent with the a priori expectation and suggests that farmers are gradually taking advantage of the mixed energy sources available to them in accordance with the prepositions of the energy stacking theory. This finding is consistent with the results of Khan, Tan, Hassan and Bilal (2022) who found evidence to justify the positive relationship between alternative energy use and agriculture sustainability. This could be attributed to the availability of various energy sources to farmers. The results further showed that total electricity use has no significant effect on agriculture value added in the short and long run. This finding is contrary to the findings of Chitedze, Nwedeh, Adeola and Abonyi (2021) who that electricity consumption does not cause agricultural growth in Nigeria. This finding could be linked to the poor and unstable power supply in Nigeria which poses a threat to the development of the agriculture sector in Nigeria. The error correction coefficient (-0.4826) is negative and significant at the 5% level, indicating that convergence to the long run equilibrium is achieved at the speed of 48.26%. The adjusted R-squared of 0.5821 indicates that 58.21% of the total variations in agriculture value added are due to changes in the energy use indicators. This shows that the model is a good fit. It is also evident from the results that the probability value (0.0000) of the F-statistic is less than 0.05, indicating that the energy use indicators are jointly significant in explaining changes in agriculture value added.

Table 3.1: Post-estimation test results

Test Type	Test Statistic	Probability value
Breusch-Godfrey Serial Correlation LM Test	0.0650	0.7987
White heteroskedasticity test	4.0271	0.7766
Ramsey RESET	0.2037	0.8173

Source: E-views Output (2025)

The post-estimation test results showed that there is no serial correlation in the model at the 5% level. This is based on fact that the probability value (0.7987) of the Breusch-Godfrey serial correlation LM test result is greater than 0.05. The results further showed that the variance of the residuals is constant over the study period. Again, there is no specification error in the model at the 5% significance level, given that the probability value (0.8173) of the Ramsey RESET result is greater than 0.05. These findings are impressive as they provide enough evidence for the reliability of the estimated ARDL model.

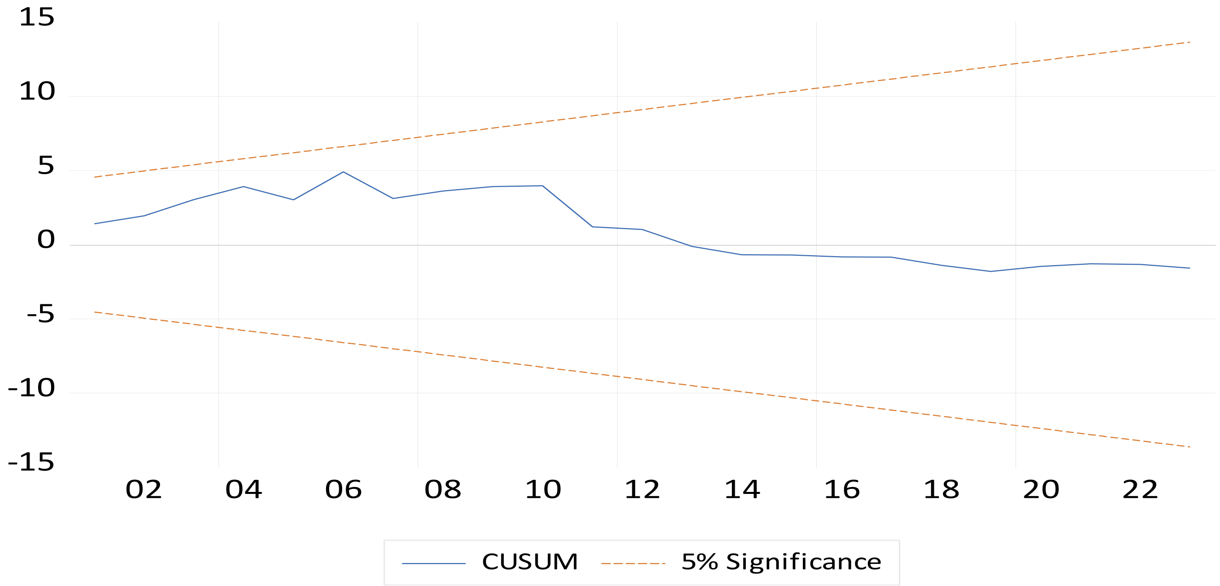

Figure 4.9: Cumulative sum (CUSUM) graph for model 1

The CUSUM graph was employed in this study to ascertain the stability of the estimated ARDL model. As observed from the results, the CUSUM graph lies within the two critical bound lines at the 5% significance level. This implies that the estimated parameters are constant over the study period.

CONCLUSION AND REMARKS

This study explores the implications of energy use on the agriculture sector in Nigeria. The energy use measures covered in this study include fossil fuel energy use, renewable energy use, alternative energy use and total electricity use. The findings showed that fossil fuel use has a significant negative effect on agriculture value added in the long run. This highlights the adverse implications of fossil fuels on agricultural productivity. The results further showed that renewable energy use affected agricultural output negatively. This finding suggests that the transition to renewable energy has not yielded positive benefits for the agriculture sector. Evidence of a positive and significant effect of alternative energy use on the agriculture sector was established in the long run. Given the findings, this study recommends that policymakers should reduce fossil fuel dependency as a source of energy by diversifying energy sources to create more opportunities for firms in the real sector to boost their output and value addition to GDP.

REFERENCES

Abosedra, S., Shahbaz, M., & Sbia, R. (2015). The links between energy consumption, financial development, and economic growth in Lebanon: evidence from cointegration with unknown structural breaks. *Journal of Energy*, *2015*(1), 965825.

Acuña-Ascencio, R., Carhuamaca-Coronel, E., & Mougenot, B. (2024). Incidence of energy consumption, mining sector and economic growth on CO2 emission levels: Evidence from Peru. *International Journal of Energy Economics and Policy*, *14*(1), 6.

Ariza, J., Vargas-Prieto, A., & García-Estévez, J. (2020). The effects of the mining-energy boom on inclusive development in Colombia. *The Extractive Industries and Society*, *7*(4), 1597-1606.

Bekhet, H. A., & Abdullah, A. (2010). Energy use in agriculture sector: input-output analysis. *International Business Research*, *3*(3), 111.

Bekun, F. V., Adekunle, A. O., Gbadebo, A. D., Alhassan, A., Akande, J. O., & Yusoff, N. Y. M. (2023). Sustainable electricity consumption in South Africa: the impacts of tourism and economic growth. *Environmental Science and Pollution Research*, *30*(42), 96301-96311.

Chandio, A. A., Jiang, Y., & Rehman, A. (2019). Using the ARDL-ECM approach to investigate the nexus between support price and wheat production: an empirical evidence from Pakistan. *Journal of Asian Business and Economic Studies*, *26*(1), 139-152.

Chinedu, U. A., Daniel, O. C., & Ezekwe, U. C. (2019). Impact of energy consumption on economic growth in Nigeria: An approach of time series econometric model. *International Journal of Academic Reserach in Economics and Management Sciences*, *8*(2).

Chitedze, I., Nwedeh, C. C. N., Adeola, A., & Abonyi, D. C. C. (2021). An econometric analysis of electricity consumption and real sector performance in Nigeria. *International Journal of Energy Sector Management*, *15*(4), 855-873.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: journal of the Econometric Society*, 1057-1072.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.

Erol, U., & Yu, E. S. (1987). On the causal relationship between energy and income for industrialized countries. *The Journal of Energy and Development*, 113-122.

Esengun, K., Gündüz, O., & Erdal, G. (2007). Input–output energy analysis in dry apricot production of Turkey. *Energy Conversion and Management*, *48*(2), 592-598.

Hassler, U., & Wolters, J. (2006). Autoregressive distributed lag models and cointegration. *Allgemeines Statistisches Archiv*, *90*(1), 59-74.

Jebli, M. B., & Youssef, S. B. (2017). The role of renewable energy and agriculture in reducing CO2 emissions: Evidence for North Africa countries. *Ecological indicators*, *74*, 295-301.

Khan, I., Tan, D., Hassan, S. T., & Bilal. (2022). Role of alternative and nuclear energy in stimulating environmental sustainability: impact of government expenditures. *Environmental Science and Pollution Research*, *29*(25), 37894-37905.

Liu, J., Wang, H., Rahman, S., & Sriboonchitta, S. (2021). Energy efficiency, energy conservation and determinants in the agricultural sector in emerging economies. *Agriculture*, *11*(8), 773.

Madzík, P., Daňková, A., Piteková, J., & Ferencz, V. (2016). Effects of the energy and mining industry on management of national competitiveness. *Acta Montanistica Slovaca*, *21*(1).

Mason, E. S. (1955). *Reports on the productive uses of nuclear energy: Energy requirements and economic growth*. National Planning Association.

Muazu, A., Yu, Q., & Liu, Q. (2023). Does renewable energy consumption promote economic growth? An empirical analysis of panel threshold based on 54 African countries. *International Journal of Energy Sector Management*, *17*(1), 106-127.

Nazir, M., Murdifin, I., Putra, A. H. P. K., Hamzah, N., & Murfat, M. Z. (2020). Analysis of economic development based on environment resources in the mining sector. *Journal of Asian Finance, Economics and Business*, *7*(6), 133-143.

Ozigbu, J. C., Ezekwe , C. I., & Morris, R. E.-O. (2025). Does energy mix matter for environmental degradation? New insights from global warming in Nigeria. *Journal of Energy Research and Reviews, 17*(6), 155–166. https://doi.org/10.9734/jenrr/2025/v17i6427

Qamruzzaman, M. (2022). Nexus between foreign direct investments renewable energy consumption: What is the role of Government debt. *International Journal of Multidisciplinary Research and Growth Evaluation*, *3*(3), 514-522.

Sims, E. A. (1989). Storage and expenditure of energy in obesity and their implications for management. *Medical Clinics of North America*, *73*(1), 97-110.

Usman, M., Anwar, S., Yaseen, M. R., Makhdum, M. S. A., Kousar, R., & Jahanger, A. (2022). Unveiling the dynamic relationship between agriculture value addition, energy utilization, tourism and environmental degradation in South Asia. *Journal of Public Affairs*, *22*(4), e2712.

Zhou, X., Huang, Z., Scheuer, B., Wang, H., Zhou, G., & Liu, Y. (2023). High-resolution estimation of building energy consumption at the city level. *Energy*, *275*, 127476.

Zou, G. (2022). Relationships between agricultural growth and energy consumption in China: Toda–Yamamoto tests. *Energy Reports*, *8*, 756-763.