African Journal of Economics and Sustainable Development
ISSN: 2689-5080
Volume 7, Issue 2, 2024 (pp. 40-52)
www.abjournals.org

ECONOMIC SUSTAINABILITY AND GAS FLARING IN NIGERIA

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Cite this article:

Adegoriola A.E., Ogiri A.I., Adeyemo T.I. (2024), Economic Sustainability and Gas Flaring in Nigeria. African Journal of Economics and Sustainable Development 7(2), 40-52. DOI: 10.52589/AJESD-MCKLK8FQ

Manuscript History

Received: 12 Nov 2023

Accepted: 26 Feb 2024

Published: 26 Mar 2024

ABSTRACT: *The crude oil exploration leads to the flaring gas, which affects Nigerian economic sustainability. The empirical study is to inquire about the profitable (economic) sustainability of the flaring of natural gaseous substances in Nigeria. The survey is to employ the ready-made design through the National Bureau of Statistics, Central Bank of Nigeria Statistical Bulletin, Department of Petroleum Resources, and World Development Indicators. The Autoregressive Distributed Lag (ARDL) model and Augmented Dickey-Fuller test are employed as the estimation technique and unit root test for long-range presence association between the exogenous and explained variables. The findings of the study showed an insignificantly positive outcome of profitable (economic) growth on natural gas flaring in Nigeria. The current employment rate showed a positively insignificant impact on the gas flare. The current oil revenue value showed a positively significant impact on gas flaring. Meanwhile, the oil revenue lag showed an insignificantly negative impact on Nigerian naturally flared gaseous substances. The research recommends that the relevant natural gas authorities should put in place stringent laws to reduce the flaring of natural gas consequences to the well-being of humans, the environment, and the economic growth and development of the country. Alternatively, the government should encourage sound and viable gas flaring processes of industrial and domestic usage.*

KEYWORDS: Economy, Sustainability, Gas flaring.

Article DOI: 10.52589/AJESD-MCKLK8FQ
DOI URL: https://doi.org/10.52589/AJESD-MCKLK8FQ

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INTRODUCTION

Energy has served as the backbone for wealth creation and human existence. Advanced and developed society has endowed with sound energetic planning and better managerial systems in order to improve the energy sources, optimistic utility and frequent supply of power. The awareness of this naturally flammable gaseous substance beneath the earth's surface has been known by humans for over a thousand years. In 1821, Fredonia town in New York illuminated the use of natural gas, which was widely used by the United States of America after the advent of the petroleum industry (Barnes *et al.*, 2006). The production of natural gas impurity has frequently been related to crude oil extraction, which would used in the generation of onsite electricity, and ground reinjection as well as pipeline transportation to natural gas purification plants to the end distribution market. In reality, the requisite technological inadequacy and high capital-intensified nature has affected the maximised profitability to be invested so as to provide natural gas amenities (Shutemov *et al.*, 2012).

The occurrence of combustible natural gaseous and liquidity substances lead not only to the flaring of natural gas during extraction of crude oil production process with the usage of vertical stack elevation on oil-well or oil-rig but also the safety of personnel and residents. In developing economies like Nigeria, the widespread of unacceptable practices has become the norm in flaring natural gas (World Bank, 2011). The Organization of Petroleum Exporting Countries (OPEC) reported over 180 trillion cubic feet and nine billion tons estimated on natural gas reserve and proven crude oil as well as 7th overall natural gas reserve manufacturer and 6th overall crude oil manufacturer, which these could last for 110 years and 37 years respectively (Atoyebi & Akinde, 2012; Adegoriola & Ben-Obi, 2022; Huang, 2002). Nevertheless, daily production of natural gas was less than 7% but more than 5% cubic feet, which means the domestic, industrial and export business markets are using only 8% for their activities. Meanwhile, 12% was re-injected into this system leaving as large as over 75% to flaring (Ayoola, 2011). Globally, Nigeria accounted for 2.5% out of over 206 trillion cubic meters of proven natural gas (Egila *et al.*, 2013).

Despite this, the Nigerian economy is now downsizing as a result of interrupted electric power supply with 0.054KWT/h consumed by over 190 million populations (Oduneka *et al.*, 2012) and 40% outrage constant power supply (Falade, 2010). In fact, this has caused environmental health pollution on earth (General Electric Energy, 2010) as well as negative effects on climate change (Energy Information Administration, 2013). Meanwhile, several reports proved that Nigeria has been ranked as the most flaring natural gas country along with Russia as the runner country in the world (Friend of the Earth, 2004; Gervet, 2007). In 1958, the Nigerian economy was partly shifted from commercial agriculture to raw oil mechanisation due to the raw oil development advent at Oloibiri in the Niger-Delta Regional Settlement (NDR) (Nnaji *et al.*, 2012) with the vast quantified and related natural gaseous substance being experienced to forgo assets for liabilities (IGU, 2000; Ukala, 2011; Chike *et al.*, 2012). Lubeck *et al.* (2007) stated that Nigeria is used to flare more than 75% of natural gaseous substances. Despite this, Nigeria is listed among the natural gas flaring countries with more than 60% (Ateveuri, 2004; Adegoriola & Suleiman, 2020; Uhren & Doucette, 2004).

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Globally, the rate of scale accounted from crude oil extraction through natural gas flaring is measured as 16%, 11% and 10% to Nigeria, Russia and Iran respectively, which World Bank set year 2030 as the stoppage deadline for flaring gaseous substance especially among the three major countries (World Bank, 2015). In addition to this, the foreign dominance by International Oil Companies (IOCs) with 94% against 6% indigenous participation (Eboh, 2015; General Electric Energy, 2010) has majorly contributed to the different environmental laws in Nigeria (Mähler, 2010). Also, natural gaseous flaring substance has been estimated to be measured for almost 410 billion standardised cubic feet in the fiscal year 2013, which loss estimation is quoted as 272.8 billion naira ($1.705 billion) reported by the Nigeria National Petroleum Corporation (Eboh, 2015).

Based on the above statements, what is the impact of flaring natural gaseous substances on the oil revenue earning in Nigeria? Will flaring of natural gaseous substances have an impact on employment opportunities in Nigeria? Will flaring of natural gaseous substances have an impact on economic growth in Nigeria? Will flaring of natural gaseous substances have a long-run relationship with Nigerian economic productivity?

REVIEW OF LITERATURES

Conceptual Review

The definition of natural gas flaring is an anthropogenic activity involving unwanted radiation from green-house gases (GHGs) that leads to worldwide heating, unbalanced earth, uncertain climatic change conditions and main natural and environmental disasters. In addition to this, natural gas flaring is an emission of a noxious mixture, which is allowed by the benzene but is harmful to human beings, lower animals, green plants and the whole geographical earth (World Bank, 1995).

Empirical Review

Osuoha and Fakutiju (2017) studied that flaring of natural gas impact in the Niger Delta region (NDR) between 1999 and 2015 was not expressly assumed but a clearly verified and supported reality and evidence. The study investigated and expressed the association between total production, utilisation and flaring cost of gas, sociable and profitable costs, and the public health effects found from flaring natural gaseous substances in the NDR (Niger Delta region) of Nigeria from 1999 downward to 2015. The findings showed that flaring of natural gaseous substances has a negative outcome on the well-being of mankind and the naturally endowed ecosystem. The deployment for availability of fund-efficient technology answers could be spelt by the raw oil organisations to reduce, increase and enhance gas flaring, revenue and the environmental quality respectively.

Njoku-Tony *et al.* (2017) studied the gas flaring impact on the cassava leaves around Utorogu gas plant, Delta State. The study examined the gas flaring impact on the cassava leaves around Utorogu gas plant, Delta State of Nigeria. The study adapted primary data collection of leaves for testing through laboratory analysis in order to test the percent. The study found that 38.00-92.00ppm, 0.05-1.20ppm, 11.00-26.40ppm, 252.00-340.00ppm 82.00-190.00ppm had been revealed as the variation of CH4, H2S, CO, SO2 and NO2 respectively while 30.50-56.33, 1.98-4.66, 4.50-7.00mol/litre and 0.03-0.15 had been revealed as the variation of

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RLWC, TCC, LEP and AAC respectively. The study showed that there was excessiveness of CO, NOx, and SOx from NESREA's little-period acceptance restricts for ambient air pollutants of 10 ppm (40-60) ppm and 100 ppm respectively. It showed the application of air waste-product important restrictive effects on the biochemistry processes of the examined leaf. It was recommended that the agencies and companies from environmental regulatory and oil exploration respectively should be able to assist in decreasing the natural gaseous substance flaring in order to reduce the damage of crop produce.

Otene *et al.* (2016) studied the prospective contraction of carbon-dioxide (CO_2) radiations from flared natural gas in Nigerian raw oil and natural gas commercial enterprise directly from different generative usage. The model adopted was the Long-range Energy Alternative Planning System (LEAP) software in order to create alternative projection between the energy demand and carbon-dioxide radiations to the year 2030. The CNG, Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG), and power generation usage as well as the gas to fertilizer (GTF) will importantly reduce CO_2 radiations in Nigerian raw (crude) oil and gaseous commercial enterprise. The results showed a reduction on green-house gases (GHG) radiations below 1990 level has reduced the CO_2 radiations through the flaring of natural gas in different productive usage in Nigerian raw oil and natural gas commercial enterprise. The outcome will improve socio-economic and commercialised enterprise growth, free-energy demand and economic generation.

Yunusa *et al.* (2016) asserted by investigating flaring of natural gas and Nigerian crude oil revenue from 2000-2014. The inferential statistical tool used was multiple regression analysis through time series data as well as unit-root for testing the stationary level. The outcomes of the study showed that flaring of natural gas has indirectly and statistically significant impact on crude oil revenues of Nigeria, which has shown the strong implementation of regulatory incentives in order to improve and increase the crude oil revenues. It was recommended that the government should seriously embrace the utilisation policy of gas and penalty increment for companies that are often involved in flaring of gas. Alternatively, electricity generation and power supply from natural gas should be the government priority as a means in order to curtail the Nigerian flared natural gaseous substance.

Omoniyi and Ubale (2015) empirically studied the flared natural gaseous substance impact in Nigeria. The methods adopted are questionnaire, interview, observation and case studies in some villages where oil is produced. The results obtained from about 90 completed questionnaires both from residents and company workers show that 80% believed that social-economic threats are contributed by gas flaring in the region while the remaining 20% believed that gas flaring is not an issue. 75% respondents said that flared gaseous substances pollute their environmental habitat with toxic compounds and elements in addition to acid rain which cause several devastating diseases such as cancers, blood disorders, bronchitis, anemia and damage to skin cells. Thus, the adverse effects of these diseases reduce the human beings' life expectancy of crude oil producing communities.

Pourhassan and Taravat (2014) examined the flaring of gas' effect on the developing countries' environmental parameters using panel data from most of the crude oil exploring nations such as Saudi Arabia, Kuwait, Qatar, Iran, Russia, Iraq, Algeria, and Tunisia from year (1994-2008). Multiple regression adopted as the inferential analysis tool for the data. The outcome disclosed the crude oil price, CO_2 radiations and the GDP for total rent of the natural resources' coefficients are fixed and statistically significant with an increase in

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0.00305. Likewise, CO_2 radiations and the GDP for total rent of the natural resources' coefficients are directly having meaningful association in the global oil reserve. The study recommended that strong incentives should be used to properly and economically use and exploit natural resources in order to reduce the loss of usage.

Beulah and Dominic (2013) asserted the flaring of natural gas consequences on social and economic health of farm households in Nigerian Bayelsa State at Ogbia Local Government Area (LGA). The use of random sampling technique for multi stage was adopted for 150 selected respondents between five farming communities with ten household's farmers from each community. The primary source for data collection was the use of structured questionnaires to collect raw information. The descriptive statistical tool was to analyse the data collected. About 70% respondents said the flared gaseous substance is a threat to their sources of livelihood and has negatively affected their well-being (food insecurity, health & building) over the years of continuous flaring. Meanwhile, gas flaring has caused air and water pollution, which 27% of the respondents have perceived in the course of study.

Atoyebi and Akinde (2012) investigated the gas flaring and power plant emissions impact on the Nigerian Niger Delta Region (NDR) socio-economic environment. The study used both secondary and primary data were employed while the Ordinary Least Square estimate was used to analyse the data. The findings showed that the gaseous substance flared reduction would advance mankind well-being and their environmental growth. They concluded that the alternative utilisation of related gaseous fuel for power generation will improve the sustenance of the masses in the Niger Delta.

METHODOLOGY

Specification of the Model

The model represents the influence of stimulation on the macroeconomic parameters on the economic performance and sustainability in Nigeria, which comprises five variables with four independent parameters and a dependent variable. The inferential statistical technique employed is a time series estimation through Autoregressive Distributed Lag (ARDL) model. ARDL will enable us to capture the impact of gas flaring on economic suitability and the long-run association among the variables. Feldman et al. (1982) opined the theoretical framework, hence the study adapted the model of Yunusa et al. (2016) which is specified below:

$$GFR = f(ECG, EMP, ORE, GUT) - - - - - - - - - - - - - - - 1$$

To capture the gas flared (GFR)'s responsiveness to the Growth (ECG), Employment Rate (EMP), Oil Revenue % GDP (ORE) and Gas Utilization (GUT), which this is expressed as the log from equations (1) above as follows:

$$InGFR = \beta 0 + \beta 1 \mathrm{InECG} + \beta 2 \mathrm{InEMP} + \beta 3 \mathrm{InORE} + \beta 4 \mathrm{InGUT} + \mu - - - - 2$$

Pesaran *et al.* (2001) deduced that the equation of Autoregressive Distributed lag (ARDL) can be expressed below:

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www.abjournals.org

$$\Delta GFRt = \beta 0 + \sum \beta 1 \Delta ECGt - 1 + \sum \beta 2 \Delta EMPt - 1 + \sum \beta 3 \Delta OREt - 1 + \sum \beta 4 \Delta GUTt - 1 + \sum \beta 5 \Delta GFRt - 1 + \mu t - 3$$

Where:

GFR = Gas Flared

ECG = Economic Growth

EMP = Employment Rate

ORE = Oil Revenue % GDP

GUT = Gas Utilization

β_0 is the constant while β_1 - β_4 are explanatory estimations to be measured and μ is an unexplained predictor. The relationship between the long-run and the short-run deviations might have occurred in the estimation of the long-run cointegration equation, which is expected to be β_1 - $\beta_4 > 0$.

RESULTS AND DISCUSSION

The data of time series are adopted in this study in order to empirically review and investigate the Nigerian economic sustainability and flaring of natural gas in order to provide a spurious multiple regression. In addition to this, unit-root, ARDL bound and estimation tests are therefore conducted in order to show the pre-test through EViews 9.0 statistical software packages.

4.1 Descriptive Statistical Analysis

Table 1: Descriptive Statistical Analysis

	GFR	ECG	EMP	ORE	GUT
Mean	667.9776	4.810000	86.09363	12.79143	828.7653
Median	715.5000	5.390000	86.40000	12.95000	269.5000
Maximum	980.7000	25.01000	90.43000	38.55000	2654.800
Minimum	138.9000	-10.80000	78.00000	0.340000	1.800000
Std. Dev.	233.1599	6.667515	2.344162	8.020903	951.2227
Skewness	-0.385717	0.345802	-0.834095	0.606134	0.900602
Kurtosis	1.881316	4.218566	4.882830	3.626139	2.209106
Jarque-Bera	3.770070	4.008238	12.91948	3.800859	7.900938
Probability	0.151824	0.134779	0.001565	0.149504	0.019246
Sum	32730.90	235.6900	4218.588	626.7800	40609.50
Sum Sq. Dev.	2609450.	2133.876	263.7645	3088.075	43431583
Observations	49	49	49	49	49

Source: *Author's Computation, 2023.*

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The descriptive statistical analysis describes the exogenous and explained variable with a total of 49 observations. The mean, maximum values, minimum values, range, standard deviation, skewness, kurtosis and Jarque-Bera stand as the key figures to be described. The outcomes of the summary showed that mean and median are shown the value of 668 and 716, 4.8 and 5.4, 86.1 and 86.4, 12.8 and 13, 828.8 and 269.5 for GFR, ECG, EMP, ORE and GUT respectively. The maximum and minimum also show the value of 980.70 and 138.9, 25.01 and -10.8, 90.4 and 78, 38.6 and 0.34, 2654.8 and 1.8 for GFR, ECG, EMP, ORE and GUT respectively. The estimation of Jarque-Bera and its probability are 3.77 and 0.15, 4.01 and 0.13, 12.92 and 0.0015, 3.8 and 0.15, 7.9 and 0.02 for GFR, ECG, EMP, ORE and GUT respectively.

Unit Root Test Analysis

The pre-test examination stands as the unit root test before carrying out the regression analysis so that the establishment of the stationary properties would be carried out from the variables considered for.

Table 2: Unit Root Test Analysis

Variable		**GFR**	**ECG**	**EMP**	**ORE**	**GUT**
With Constant	t-Statistic	-6.2628	-7.1012	-2.2073	-6.4184	-2.9815
B	Prob.	0.0000	0.0000	0.2066	0.0000	0.0451
		***	***	No	***	**
With Constant & Trend	t-Statistic	-6.5226	-7.0061	-0.7140	-6.4499	-3.6608
	Prob.	0.0000	0.0000	0.9650	0.0000	0.0368
		***	***	No	***	**
Without Constant & Trend	t-Statistic	-6.3390	-7.1642	-2.1501	-6.4878	-2.7746
	Prob.	0.0000	0.0000	0.0317	0.0000	0.0067
		***	***	**	***	***
Stationary Status		I(1)	I(1)	I(1)	I(1)	I(0)

Source: *Author's Computation, 2023.*

The explained variable is GFR, while the exogenous variables are ECG, EMP, ORE and GUT), which were tested through the Augmented Dickey-Fuller (ADF) test. GUT was estimated as I(0) stationary level, while I(1) stationary level was the estimation for GFR, ECG, EMP and ORE respectively.

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Bounds Test for Co-integration Result

The ARDL Bound test for co-integration is often shown in most cases is not orderly stationed at the same series among the relationships of the long-run equilibrium.

Table 3: ARDL Bounds Test Result and Critical Value Bounds

Null Hypothesis: No long-run relationships		
Test Statistic	Value	K
F-statistic	8.113400	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Source: *Author's Computation, 2023*

Under this table, the calculated F-statistic is more than critical values at 8.113400 > 10%, 5%, 2.5% and 1% significant level respectively in terms of long-run association existence among explained and exogenous parameters. The interpretation of this is to call for the rejection of the null hypothesis of the no cointegration at the bound value.

Estimation of ARDL Statistical Analysis

Table 4: Estimation of Long Run Coefficients

Dependent variable is GFR Using the ARDL Approach ARDL (2, 0, 0, 2, 0) Selected based on Akaike info criterion (AIC)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GFR(-1)	0.647981	0.144612	4.480829	0.0001
GFR(-2)	0.207245	0.129379	1.601844	0.1175
ECG	3.054030	2.390117	1.277775	0.2091
EMP	1.691278	5.811965	0.290999	0.7726
ORE	7.643798	2.037582	3.751405	0.0006
ORE(-1)	-1.177881	2.361631	-0.498758	0.6208
ORE(-2)	-8.344630	2.345065	-3.558380	0.0010
GUT	-0.045580	0.015325	-2.974218	0.0051
CointEq(-1)	-0.144773	0.101243	-1.429961	0.1609
C	1.160749	506.5691	0.002291	0.9982
R-squared	0.878513	Mean dependent var		685.7000
Adjusted R-squared	0.852937	S.D. dependent var		219.8034
S.E. of regression	84.29188	Akaike info criterion		11.87687
Sum squared residual	269994.6	Schwarz criterion		12.23115

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Log likelihood	-270.1063	Hannan-Quinn criter.	12.01018
F-statistic	34.34897	Durbin-Watson stat	1.821924
Prob. (F-statistic)	0.000000		

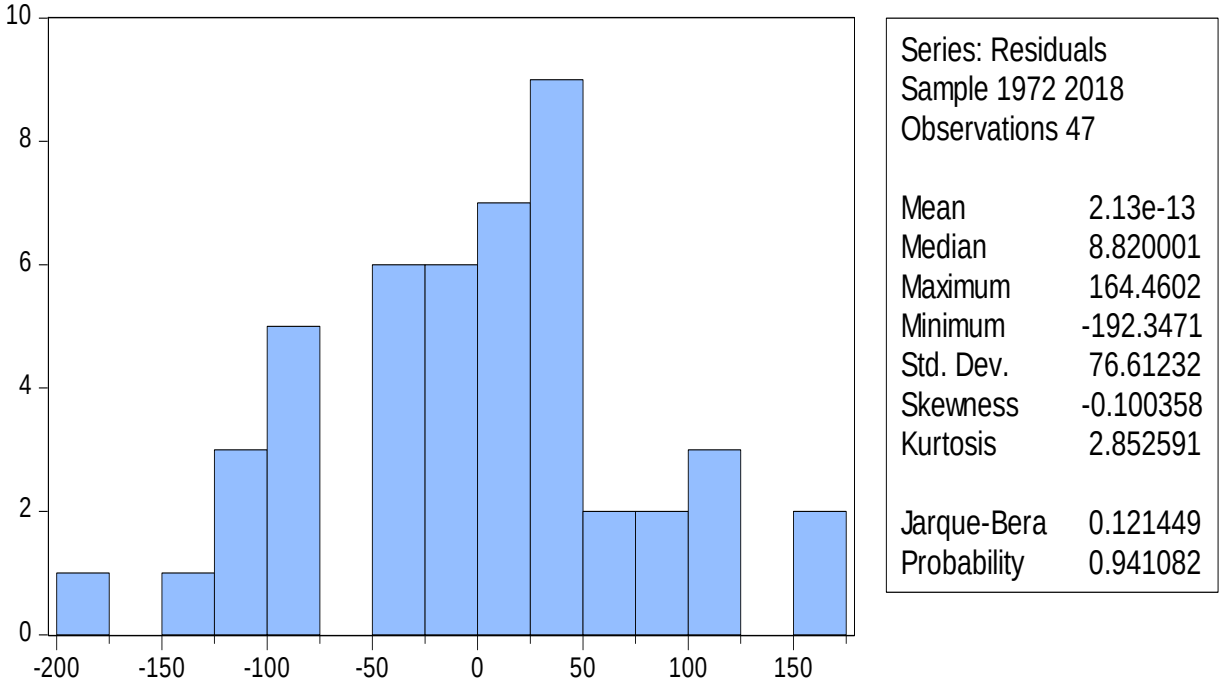
Source: Author's Computation, 2023.

The findings revealed that one time-lag of GFR showed a directly significant impact by the independent variable, while current value of ECG showed a positively non-significant impact on Nigerian gas flared. The EMP current value showed positively insignificant impact on gas flared. The ORE value showed a positively significant impact on gas flared while one period lag of ORE' one lag time showed a negatively non-significant impact on gas flared in Nigeria. The ORE's second time lag showed negative but significant impact gas flared in Nigeria. Gas utilization has a negative but significant impact with gas flared. In addition, the determination coefficient of (R^2) showed 88% variations in natural gas flared as an explanatory variable, while the adjusted R^2 still showed 85% variation in natural gas flared as the explanatory variable. The F-statistic and probability have shown 34.34897 and 0.000000 respectively, which the good fitness has been shown between the explanatory and dependent variables.

Residual Diagnostic Test

Since the outcome of the Normality test, Heteroscedasticity tests, and Serial Correlation of Breusch-Godfrey is 0.941082, 0.310737 and 0.6528 respectively, which are more than 0.05 levels of significance. Therefore, the model has directly passed the specific ARDL model.

Figure 1: Normality Framework



Source: *Author's Computation, 2023.*

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DISCUSSION OF RESULTS

The results show that an economic growth increment has led to an increment in gas flaring in Nigeria. In the operation of stepping-up the output, the economic sector will lead to an increase in gas flaring by oil companies, manufacturing companies and others companies that use gas in the production process. Increased gas flaring will alter the economy, reduce output and economic growth and have a negative impact on economic sustainability. The relationship between flaring of gas and employment generation is positive in the short-run. It has the tendency of reducing employment generation in Nigeria because gas flaring is an economic waste which would be used as an alternative source of energy and can serve as a source of employment for the teaming unemployed youth in Nigeria. As reduced gas flaring will improve the economy sustainability and create more job opportunities for the youth in Nigeria.

A drastic reduction in gas flaring Nigeria and effective utilization of gas can increase government revenue from the energy sector. The government should continue to discourage flaring gas by crude oil companies by enforcing penalties and fines on companies that flared gas beyond the permitted rate. This should increase government revenue and discourage gas flaring. There should be full gas utilization as an alternate way for energy source and gas exportation since Nigeria has gas in abundance, which contributes to Nigerian foreign exchange earnings and reserves.

Conclusion and Recommendations

Generally, this investigation empirically examines economic sustainability on natural gas flaring in Nigeria. We have robust evidence that economic growth, employment rate, oil revenue and gas utilization impact on gas flaring in Nigeria. The investigation carried out showed that the future-time association is present between the variables. Employment generation and economic growth have insignificant impact on the Nigerian gas flare. Likewise, oil revenue is significantly impacted by gas flares. Also, gas utilization has a significant impact with gas flared in Nigeria. Based on this, there must be a continuous drive and effort from the government in order to end gas flaring in Nigeria, which helps to protect our environment and achieve economic sustainability in Nigeria.

The conclusion of the research has proffered recommendations that the government should make stringent rules and regulations that will reduce the consequence of flaring natural gaseous substances on the environmental, mankind well-being and productive growth of a country through sanctions, fines payment, licence retrieve of and other capital punishments. There is an urgent need by the government to encourage the process of gas flared as an alternative source of domestic uses. This can serve as an alternative source of energy and meet the cooking needs of millions of Nigerians. There should be an amendment of the 1984 Associated Gas Re-injection (Continued Flaring of Gas) Regulation whichever is more applicable. This will force the oil companies to use technology to reduce gas flaring rather than allow some oil companies. There is a need for the government to have political will by engaging the natural gas flaring companies with the modern methods of flaring natural gas in Nigeria.

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Declaration of Conflicting Interest

The authors declare that they have no known conflicting financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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