Trade-Off between Gas Production and Gas Flaring in Nigeria

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ABSTRACT

This paper, with the aid of econometric models and statistical inference, determines the effects of gas flaring on Nigerian economic development. Using multivariate regression technique to compute basic statistics for gas flaring data in Nigeria, we consider its impact and describe a nonlinear tradeoff between gas production and flaring on Nigerian economic development. The results show that Gross Domestic Product (GDP) increases with increase in gas production, also, an increase in gas production in turn leads to increase in gas flaring. Increase in gas flaring is as a result of Government wavers in policy and decision making, corporate reluctance, etc. From the results, a more robust GDP would be accounted for if gas flaring reduces with increase in gas production. We therefore recommend that the National Energy Policy 2003 aimed at achieving sustainable development should be made effective and the shortcomings in the policy be redressed in order to achieve the objectives of reducing gas flaring menace and also enhancing economic development.

(Keywords: gas flaring, gross domestic product, per capita income, investment, econometric model, statistical inference)

INTRODUCTION

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkanes, and sometimes, a small percentage of carbon dioxide, nitrogen, and/or hydrogen sulfide. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure supplied by existing under the surface over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.

Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. It is a non-renewable resource. Natural gas is found in deep underground rock formations or associated with other hydrocarbon reservoirs in coal beds and as methane clathrates.

It is a known fact that exploration of oil and gas resources has several benefits that enhance economic development of every oil and gas-producing country, it also serves as a strong base for wealth creation. Contrary to the economic and industrial benefits, there are negative and unhelpful consequences associated with crude oil extraction where it is not well managed (Amorin and Broni-Bediako 2013). Gas flaring is one of the major depressing environmental and economic concerns in the oil industry in recent times.

"*When you drill for oil, you also get gas. In an ideal world this associated gas would be sold to consumers, or it would be used to generate power and then resold as electricity. But this requires costly investment into pipelines, power plants, and other infrastructure. Therefore, in practice, some oil producers opt to sell the oil and burn the gas. This is known as gas flaring*" (Ebrahim and Friedrichs 2013).

That is, gas flaring is the burning of natural gas that is associated with crude oil when it is pumped up from the ground. From statistics, Nigeria is currently the second largest gas-flaring country in the world after Russia (IRIN 2015; Ndubuisi and Olaode 2015).

Each oil and gas producing country has a body overseeing the production and distribution of oils and gases with their respective vision. In Nigeria, the Nigerian National Petroleum Corporation's (NNPC) vision is to make Nigeria the leading Liquified & Natural Gas (LNG) producing nation in the world and to promote sufficiency in the domestic power supply. They intend to achieve this goal by monitoring the commercialization of Nigeria's abundant natural gas reserves, promoting viable LNG projects, power plants and associated gas projects. Unfortunately, the vision is being jeopardized by flaring of gas.

Nigeria is one of the most richly endowed countries in Africa with abundant diversity and large proportions of oil and gas reserves. According to the statistical bulletin of the Central Bank of Nigeria (CBN) (2004), Nigeria earns 95% of its foreign exchange from oil and gas productions and over 80% of government revenues from oil and gas industries. Only 20% of the 3.8 billion standard cubic feet of gas produced daily in Nigeria is utilized by local industries and/or re-injected into the ground for future harvesting by oil producing companies. Over 75% of the total production flared (Obozua, 2002; CBN, 2004). Socio-economic development in the Niger Delta region, which happens to be the main region of oil and gas production in Nigeria has been dealt a great blow as a result of gas flaring especially in the region.

According to the National Energy Policy 2003, Nigeria has an established natural gas reserves of about 163 trillion standard cubic feet**,** which in energy terms is substantially larger than its oil resources, and as at 2001, over 50% of the produced gas (mainly associated gas) was flared. Ibitoye (2014) gave three major reasons why most of the associated gas produced during oil extraction is flared: firstly, domestic demand for natural gas is not large enough to utilize all the associated gas, if recovered; secondly, the high cost of recovery of associated gas compared to non-associated gas and lastly, the inadequacy of gas infrastructure for distribution of gas to potential consumers.

Though, flaring of gas is thought to cause high degree of economic waste (Iyoha and Adamu, 2002), this work aims at analyzing the effects of gas flaring and suggesting possible ways of reducing gas flaring menace to the barest minimum.

Gas flaring Regulations in Nigeria

Crude oil was first discovered in commercial quantities in Nigeria in 1956 while oil production started in 1958. Gas flaring began at the onset of oil production and so did a realization of its notoriety (ERA 2005).

The Petroleum Act of 1969 was the first legal act established to monitor the activities of the Nigerian Petroleum Industry. In reality the law was designed for crude oil exploitation as gas had not obtained recognition as a commodity in its own right by then. As a precautionary measure, the Minister of Petroleum was given authority to make adjustments regarding licenses and leases given under the Act, including the prevention of pollution. One of the adjustments made by the Minister was the Petroleum Act (Drilling and Production) Regulations of 1969 which required the submission of a feasibility study for gas utilization within five years after production start date. Nonetheless, the regulations declined to specify precise sanctions for companies who breached this regulatory requirement. Additionally, there were no legal obligations under the regulations for the reduction of gas flaring before and after the submission of the feasibility study for gas utilization (Orji, 2014). The lapses in the regulations were therefore exploited by oil-producing companies.

In 1973, a Petroleum Amendment Decree was approved in which associated gas could be taken and used without royalty payments. This Decree was meant to encourage harnessing of associated gas as associated gas could be taken and utilized without royalty payment. The Nigerian Government was therefore at liberty to exploit oil companies of their associated gas for free and convert it for domestic uses and other economic activities. Nonetheless, the Petroleum Amendment Act of 1973 also failed to control gas flaring because the Nigerian Government did not have the essential infrastructure for the usage of the associated gas (Orji, 2014).

The Associated Gas Re-injection Act was passed in 1979. By this legislation no company was to flare gas after January 1984 without special permission from the Minister of Petroleum Resources. The penalty for the original enactment was punishment by forfeiture of concession (Flaring Policy and Regulation in Nigeria, 2014).

The penalty under the Associated Gas Re-injection Act was seen as too severe by most stakeholders and hence there was a failure to enforce this sanction. Lack of infrastructure for gas utilization and the inability of the government to contribute its share to the cost of building gas re-injection facilities based on existing joint venture agreements with oil-producing companies led to the failure of the Associated Gas Re-injection Act (1979).

The penalty for not re-injecting associated gas was changed to a low fine in 1984 which made gas flaring a much cheaper option for companies compared to the alternatives of marketing or re-injection. An oil company was quoted then as stating that it was cheaper for it to flare gas at a cost of $1 million (US) as against the $56 million (US) cost of switching from water to gas injection (Flaring Policy and Regulation in Nigeria 2014). Although the fine was reviewed and increased a couple of times between 1990 and 1998, the amount remained significantly low compared to the cost of alternatives.

The National Energy Policy (NEP) was introduced due to the apparent failure of previous legislations on gas flaring. With the aim of eliminating gas flaring by year 2008 and creating an economical and environmentally friendly operation via substituting oil for gas. In the light of this, the Federal Government of Nigeria had announced December 2008 deadline to end gas flaring in the country. The residents of Ibeno, host community of Mobil Producing Nigeria in Akwa Ibom state, have this to say on the issue of zero gas flare:

The end of 2008 is around the corner, only two months away, and yet nothing has been done. Will they (Federal Government of Nigeria) do it by magic? It is like saying that a woman will give birth without going through the process of pregnancy. If they are sincere and serious, by now work should have started, but we have not seen anything yet to suggest that there is any commitment to end gas flaring. They (oil companies) are merely playing games with the issue of gas flaring. They cannot do this in their home countries. You can see that it is still business as usual. They will still shift the deadline and until the government gets serious with the issue we shall continue like this. (The Guardian, 2008).

MATERIALS AND METHODS

To determine the impacts of gas flaring, we formulate the following economic models relating Gross Domestic Product and Per Capital Income as major economic indicators.

$GDP_{ED} = f (EXP_{TO}, FED_{TR}, INV_{ST}, GAS_{FL}, \varepsilon)$ **(1)**

$PCY_{ED} = f (EXP_{TO}, FED_{TR}, INV_{ST}, GAS_{FL}, \varepsilon)$ **(2)**

Where,
GDP = Y_1, is Nigeria's real GDP used as a proxy for economic growth

PCY= Y_2, is Nigeria's per capital income also used as a proxy for economic growth.

EXP=X_1, is Nigeria's total export

FED = X_2, is total federally collected revenue

INV = X_3, is investment in Nigeria

GAS_{FL} = X_4, is gas flared dummy (gas flare = 1, no gas flare = 0) and ε is the random error term.

Since economic theory does not indicate the precise mathematical form of relationship among the variables, different functional forms of the above models including the linear, semi-logarithm, logarithm and exponential functions were fitted. However, the lead equations were chosen on the bases of economic, statistical as well as econometric criteria. The logarithmic and exponential functions were fitted for real gross domestic product and per capita income models respectively as follows:

$$\ln Y_1 = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 X_4 \quad \textbf{(1a)}$$

$$e^{Y_1} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \quad \textbf{(1b)}$$

$$\ln Y_2 = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 X_4 \quad \textbf{(2a)}$$

$$e^{Y_2} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \quad \textbf{(2b)}$$

Where the variables are as defined earlier in Equations (1) and (2) above. The Ordinary Least Squares (OLS) technique was used to estimate the regression parameters.

Hypothesis Testings

Given the data in Table 6 (Appendix), we conducted a test of hypothesis to determine the influence of gas flaring on economic development. The results of the analysis are as shown in Tables 3 - 4 and Figures 1 – 2.

Hypothesis 1

H_0: Gas flares have no significant impact on Nigeria economy

H_1: Gas flares have significant impact on Nigeria economy at $\alpha = 0.05$.

Using the statistic: $t = \frac{\hat{\beta}_i}{S\hat{\beta}_i}$

Decision rule: Reject H_0 if $t_{cal} > t_{tab}$, otherwise do not reject.

Alternatively, reject H_0 if $P < 0.05$, otherwise do not reject.

Hypothesis 2

H_0: The regression model is not adequate for the test of gas flares' impact on PCY.

H_1: The regression model is adequate for the test of gas flares' impact on PCY at $\alpha = 0.05$

Hypothesis 3

H_0: The regression model is not adequate for the test of gas flares' impact on GDP.

H_1: The regression model is adequate for the test of gas flares' impact on GDP at $\alpha = 0.05$

Using the statistic: $F = \frac{R^2/K}{(1 - R^2)/[n-(K+1)]}$

Decision rule: Reject H_0 if $F_{cal} > F_{tab}$ otherwise do not reject. Alternatively, reject H_0 if $P < 0.05$, otherwise do not reject.

RESULTS AND DISCUSSIONS

Test for Difference of Means

The results of the test for difference of means of important parameters of economic growth such as GDP and per capita income before and after the incidence of flares are shown in Table 3.

Table 1: Nigeria Gas Production by Company (MSCF).

COMPANIES	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CHEVRON	149,361	186,566	209,974	229,972	210,200	193,802	205,601	224,715	187,509	192,033
MOBIL	160,482	122,788	241,900	255,314	144,904	181,314	156,319	148,614	178,073	201,351
SHELL	549,448	528,199	534,636	503,922	520,905	343,207	489,412	498,412	471,804	531,776
AGIP	222,434	235,166	270,434	218,706	270,124	281,751	301,705	326,573	204,522	317,609
ELF	26,495	36,570	24,157	43,947	42,840	35,649	36,401	38,509	35,077	41,703
ASHLAND	43,415	41,887	36,104	57,377	40,966	35,933	37,811	34,313	32,710	41,033
TEXACO	29,495	27,288	23,279	31,898	36,890	44,915	43,817	44,117	451,084	38,873
PAN OCEAN	3,343	14,704	12,054	14,837	18,290	17,412	17,007	18,049	16,107	18,235
AGIP ENERGY	9,038	7,546	8,441	7,164	7,817	7,984	9,715	9,193	9,214	10,101
TOTAL	**1,193,411**	**1,200,709**	**360,968**	**1,393,139**	**1,292,934**	**1,141,967**	**1,297,788**	**1,343,718**	**1,586,100**	**1,392,714**

Table 2: Gas Flaring in Nigeria by Companies in Million Standard Cubic Feet (MSCF).

COMPANIES	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CHEVRON	131,556	178,276	202,455	222,822	206,696	176,966	184,803	174,384	156,088	148,013
MOBIL	153,190	110,117	85,279	128,412	92,368	116,465	104,547	121,107	134,329	117,834
SHELL	330,187	372,586	371,471	370,296	371,362	222,013	201,021	196,406	173,501	182,601
AGIP	138,672	144,468	166,020	157,020	141,332	150,690	143,327	151,071	137,037	123,115
ELF	14,439	23,080	23,017	42,558	40,781	33,894	96,403	54,805	72,707	68,403
ASHLAND	33,506	32,337	34,230	54,054	28,412	32,559	41,716	26,903	29,314	23,516
TEXACO	29,351	27,110	23,151	31,584	34,761	44,770	52,135	53,209	49,148	51,712
PAN OCEAN	2,900	13,676	11,521	14,124	17,412	16,576	15,509	13,608	11,709	10,227
AGIP ENERGY	8,967	7,479	8,384	7,748	7,748	7,914	8,311	8,278	7,183	6,473
TOTAL	**845,768**	**909,158**	**925,827**	**1,208,014**	**940,871**	**801,847**	**847,772**	**799,771**	**771,016**	**731,894**

Table 3: Test of Differences of Means of GDP and PCY (Gas Flares).

Economic growth parameter	Mean Differences	D.F.	t-value	p-value
Gross domestic product (GDP)	4131.9	46	8.294	<0.0007*
Per capita income (PCY)	1675.3	46	5.187	0.0004*

* Significant at the 5% level
Source: Computed from Data in Table 6

Table 4: Factors Affecting Economic Growth in Nigeria (Logarithmic).

Variable	GDP Model [logarithmic function *(1a)*]			PCY Model [logarithmic function *(2a)*]		
	Estimated Coefficients	t-Statistics	p-value	Estimated Coefficients	t-Statistics	p-value
Total export	7.133	4.126	0.011*	5.211	3.475	0.037*
Total fed revenue	0.003	2.750	0.004**	0.026	2.059	0.006**
Investment	0.051	0.354	0.037*	0.074	4.593	0.000**
Gas flares	0.302	1.114	0.031*	.321	1.880	0.018*
Summary of Statistics	F-statistic = 33.053 R^2 (adj) = 0.675 n = 48 sig = .002[a]			F-statistic = 15.316 R^2 (adj) = .559 n = 48 sig = .001[a]		

** Highly significant at the 5% level
* Significant at the 5% level
Source: Computed from Data in Table 6

Table 5: Factors Affecting Economic Growth in Nigeria (Exponential).

Variable	GDP Model [logarithmic function *(1a)*]			PCY Model [logarithmic function *(2a)*]		
	Estimated Coefficients	t-Statistics	p-value	Estimated Coefficients	t-Statistics	p-value
Total export	4.262E-05	3.005	0.000**	2.951E-04	1.574	0.002**
Total fed revenue	0.002E-01	4.160	0.000**	0.007E-05	5.704	0.005**
Investment	0.22E-05	0.420	0.046*	0.255E-01	4.913	0.001**
Gas flares	0.010	5.537	0.041*	0.097	1.131	0.044*
Summary of Statistics	F-statistic = 48.258 R^2 (adj) = .862 n = 48 sig = .000[a]			F-statistic = 18.351 R^2 (adj) = .628 n = 48 sig = .000[a]		

** Highly significant at the 5% level
* Significant at the 5% level
Source: Computed from Data in Table 6

Table 6: Data.

Year	[2]Gas flared in mcm*	[2]Invest-ment	[1,2]PCY	[2,6]GDP	[2]Nigeria total export	[2]Total federally collected revenue (*Millions of Naira*)
1960	-	6.01	567	50.936	-	-
1961	-	6.93	551	51.034	-	-
1962	-	6.59	553	53.127	-	-
1963	-	7.28	582	57.127	-	-
1964	-	8.55	606	60.541	-	-
1965	-	11.64	624	63.498	-	-
1966	-	10.94	582	60.799	-	-
1967	-	9.2	485	51.227	-	-
1968	-	8.07	482	50.588	-	-
1969	-	9.28	625	62.829	-	-
1970	7954	17.46	767	78.540	885.4	634
1971	12790	22.84	1055	89.723	1293.4	1168.8
1972	16848	23.86	1002	92.741	1434.2	1405.1
1973	21487	28.45	1068	97.741	2278.4	1695.3
1974	26776	29.19	1192	108.657	5794.8	4537.4
1975	12333	43.88	1245	102.9770	4925.5	5514.7
1976	20617	58.72	1281	112.280	6751.1	6765.9
1977	20952	65.68	1480	109.050	7630.7	8042.4
1978	19440	47.63	1513	112.180	6064.4	7371.0
1979	26073	41.69	1393	119.770	10836.8	10912.4
1980	22904	47.31	1438	124.801	14186.7	15233.5
1981	14162	45.96	1515	108.420	11023.3	13290.5
1982	11940	35.92	1419	108.160	8206.4	11433.7
1983	11948	29.25	1359	102.440	7502.5	10508.7
1984	12817	19.87	1068	92.502	9088	11253.3
1985	14846	18.32	1062	106.950	11720.8	15050.4
1986	13197	14.11	973	109.650	8920.6	12595.8
1987	12291	17.40	901	108.890	30360.6	25380.6
1988	14737	19.43	940	119.660	31192.8	27596.7
1989	18730	22.65	952	128.280	57971.2	53870.4
1990	21820	22.27	995	138.790	109886.1	98102.4
1991	24588	33.77	1040	145.390	121535.4	100991.6
1992	25406	41.99	978	149.690	205611.7	190453.2
1993	25908	53.10	971	152.930	218770.1	192769.4
1994	26216	54.92	945	151.980	206059.2	201910.8
1995	26070	50.69	940	155.920	950661.4	459987.3
1996	26820	50.47	954	165.890	1309543.4	520190
1997	26548	50.48	960	172.400	1241662.7	582811.1
1998	26652	52.23	965	174.235	751856.7	463608.8
1999	26759	52.48	996	173.784	1188969.8	949187.9
2000	27552	52.96	1024	175.124	1945723.3	1906159.7
2001	27665	54.48	1045	179.258	2001230.8	2231532.9
2002	27745	56.12	1145	184.124	1882668.2	1731837.5
2003	28006	56.79	1187	184.967	2889846.7	2575095.9
2004	28123	59.47	1198	186.478	2899967.8	2634783.9
2005	28196	61.25	1245	189.357	2987645.5	2798126.8
2006	28264	61.85	1298	195.459	3056834.8	2976734.8
2007	28929	64.45	1445	208.681	3409126.6	3212836.1

Source: [1] Arosanyan (2005)
[2]CBN Bulletin, 2000, 2003, 2007 ,Dec. *million cubic metre
[6]Iyoha and Ekanem (2004).

Regression Results

The result of the OLS estimates of the regression parameters in Equations (1a), (1b), (2a) and (2b) for GDP and PCY are presented in Tables 4 and 5 respectively. The values of the R^2_a of 68%, 86%, 56% and 63% respectively indicate that the fits of the models are very satisfactory. It therefore implies that the independent variables accounts for about 68%, 86%, 56% and 63% of the total variations in GDP and PCY, respectively.

The overall regression models contribute significantly for the prediction of GDP and PCY, as indicated by the F-statistic and their corresponding P-values in Tables 4 and 5; this shows that the regression models are adequate for the test of gas flares' impact on GDP and PCY. In terms of statistical significance, the individual estimated parameter coefficients are all statistically significant at 5% level as indicated by the t-values and corresponding p-values given in Tables 4 and 5.

The performance of the estimated parameters in terms of expected signs, with the exception of GAS_{FL} coefficients (i.e., $ß_4$ and φ_4), is quite satisfactory as they conformed to apriori expectations. The influence of gas flaring on economic growth may be adduced to the fact that the Nigeria government has been silent on genuine zero-gas-flares policy as some who are in government cabinet and are sabotaging derive huge revenue from gas flaring. For instance, gas flared accounted for a receipted revenue of N4, 778,135,798.10 and N3,654,380,194.44 in 2003 and 2004 respectively (CBN BOD Annual Report, 2004: 56-57). Nevertheless, this has created an avenue for further research in this area.

Graph Results

Figures 1 and 2 relate GDP, PCY and the explanatory variable (Gas flaring). Figure 1 shows that GDP increases as gas flaring increases. Also, in Figure 2, PCY increases as gas flaring increases. These confirm the results obtained in Tables 4 and 5.

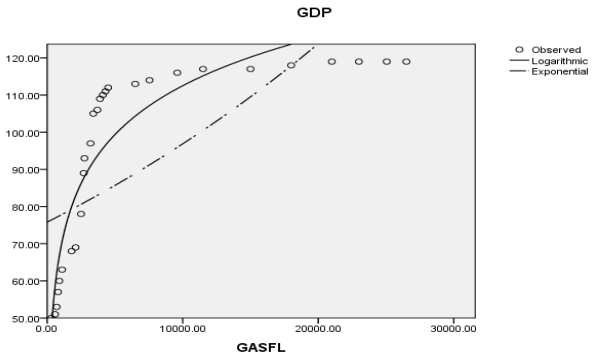

Figure 1: Logarithmic/Exponential Graph Relating GDP and Gas Flaring in Nigeria.

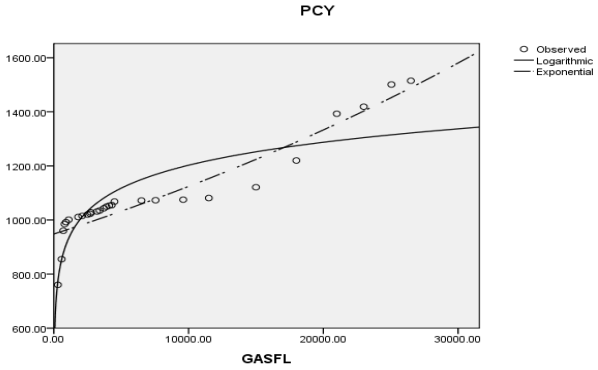

Figure 2: Logarithmic/Exponential Graph Relating PCY and Gas Flaring in Nigeria.

Figure 3: Gas Flaring.

Figure 4: Gas Flaring.

CONCLUSION

The effects of gas flaring was analyzed with the aid of a multiple regression model. Rather than its expected negative impact on economic growth, gas flaring impacted positively on it. The reason being that the Federal Government of Nigeria derives huge revenue from gas flaring activity. For instance, in 1984 and 1990 government requested oil companies to pay the fine of 2,000 Naira and 50,000 Naira respectively per thousand standard cubic feet of gas flared. Companies who paid these fines were issued certificates to further persist in the flaring of natural gas.

Today, the Niger Delta is in turmoil, restive, poor, backwards, and neglected. The attitude of the Nigerian State and the oil companies has been that of insensitivity, negligence and contempt. Plunder and impoverishment are very strong words but they fail to capture the depth of poverty, misery and sorrow visited on this once beautiful region of Nigeria. The people of the Niger Delta are becoming restive day by day and are unleashing and at the same time suffering terror every moment. We therefore made the following recommendations in attempt to salvage the situation:

1. Strict environmental standards for air, land and water pollution should be enacted and enforced. The Environmental Protection Agency (EPA) should be properly strengthened for this task.

2. Deadline to end gas flaring in the country should be feasible. However, there should be gas-to-liquid conversion projects in different parts of the country. This would provide gas feeds for oil recovery and significantly reduce routine gas flaring. Soonest, this would subsequently lead to zero gas flares in Nigeria.

3. Community participation and involvement in setting, monitoring and enforcing environmental standards should be encouraged. One way to achieving this is by negotiated agreements backed by local laws and institutions between the polluting party (oil companies) and the affected communities in the Niger Delta.

RECOMMENDATIONS

The National Energy Policy 2003 aimed at achieving sustainable development should be made effective and the shortcomings in the policy be redressed.

Also, fines for defaulters should be increased and the penalty be severed. Unlike in the past, by the Associated Gas Reinjection Act 1979, fee charged for flaring was fixed at 0.50 Naira per million cubic feet (mcf) but was from January 1998 increased to 10 Naira per mcf, yet, this obnoxious act still persist.

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