A FINAL REPORT ON

GREENHOUSE GAS EMISSIONS FROM OIL AND GAS COMPANIES IN NIGER DELTA REGION BETWEEN 2018 AND 2019: EXAMINATION OF THE COMPLIANCE PRACTICE TOWARDS IMPLEMENTATION OF THE PARIS AGREEMENT ON REDUCING GREENHOUSE EMISSIONS

SUBMITTED TO

CLIMATE AND SUSTAINABLE DEVELOPMENT NETWORK (CSDevNet)

AND

PAN-AFRICAN CLIMATE JUSTICE ALLIANCE (PACJA)

PREPARED BY

SUSTAINABLE DEVELOPMENT SOLUTION NETWORK, FEDERAL UNIVERSITY OF PETROLEUM RESOURCES, EFFURUN (SDSNFUPRE),

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OCTOBER, 2020

STUDY PAGE

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CERTIFICATION

I, Dr Akinyemi.O. Ogunkeyede certify that this report submitted by SDSN-FUPRE to CSDevNet and PACJA is an outcome of independent and original work.

ASSESSMENT PERIOD

This study covered only Greenhouse Gas (GHG) emission between 2018 and 2019.

Report Version	**1.0**
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Acknowledgement

The research team of SDSNFUPRE appreciates the funding support of the Climate and Sustainable Development Network (CSDevNet) and Pan African Climate Justice Alliance (PACJA) towards the completion of this project and the good working relationship exhibited throughout this project. Furthermore, we appreciate the National Oil Spill Detection and Response Agency (NOSDRA), Department of Petroleum Resources (DPR), Federal Ministry of Environment (FMEnv) and others that supported the team with relevant data towards the completion of this project.

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LIST OF ABBREVIATIONS AND ACRONYMS

µg/m3	-	Microgram per Meter Cube
CO_2	-	Carbon dioxide
dB (A)	-	Decibel Amperes
DPR	-	Department of Petroleum Resources
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
FMEnv	-	Federal Ministry of Environment
GHG	-	Greenhouse Gas
INDC	-	Intended Nationally Determined Contributions
IPCC	-	Intergovernmental Panel on Climate Change
UNFCCC	-	United Nations Framework Convention on Climate Change
NCCPRS	-	National Climate Change Policy Response Strategy
NDCs	-	Nationally Determined Contributions
FNC	-	First National Communication
CO	-	Carbon monoxide
Sox	-	Oxide of Sulphur
H_2S	-	Hydrogen Sulphide
O_3	-	Ozone
VOC	-	Volatile Organic Compounds
SPM	-	Suspended Particulate Matter
NAAQS	-	National Ambient Air Quality Standards Nigerian
KW	-	Kilowatts
m/s	-	minutes per second
NAOC	-	Nigeria Agip Oil Company
NDWEST	-	N.D.Western Limited
NE	-	North East
NOSDRA	-	National Oil Spill Detection & Response Agency
NOx	-	Nitrogen Oxides
N.W.	-	North West
ppm	-	Part per million
PPMC	-	Pipelines and Product Marketing Company Limited
S.E.	-	South East
SPDC	-	Shell Petroleum Development Company
S.W.	-	South West

Executive summary

The unpredictable changes in weather conditions, global warming, climate change, ecosystems degradation and loss of biodiversity, as well as the decline in quality of life and life expectancy, necessitated the present investigation of air quality concerning gas flaring and oil spillage activities during oil exploration in the Niger Delta region of Nigeria. Also, the study assessed the compliance level, implementation of the country's Nationally Determined Contributions (NDCs), and the Paris agreement as a means to mitigate greenhouse gas emissions within the region. The meteorological parameters and ambient air quality were assessed in three major gas flaring sites of Delta state viz: Eruemukowhare, Irri and Kwale oil locations. The wind speed, temperature, pressure, and relative humidity were determined at the sampling stations. Also, the smoke density, particulate matter (PM_{10}), nitrous oxide (NOx), sulfur oxides (Sox), Ozone (O_3), carbon monoxide (CO) were determined at three different times. The direction of the wind was considered during the sampling with Aeroqual Gas Monitor (500 Series), to determine the concentrations of NO_2, SO_2, CO, VOC and O_3. *Met One Particulate Counter* was used to detect the suspended particulate matter (SPM). The obtained data were statistically analysed for mean results as follows; PM_{10} (22.25) µg m^{-3}, NO_2 (0.034) ppm and CO (1.46) ppm, SO_2 and O_3 were found below the detectable limits of the monitoring device. The study results showing that the greenhouse gases (GHG) were all within the recommended limits, however, does not undermine the significance of these gases and contributions of the oil and gas sector. It thus showed that these gases were transported quite a distance into the atmosphere, and not within the sampling reach, except an aerial or space sampling was conducted to about 4-10km above sea level. The calculated CO_2 released into the environment from oil spills in the Niger Delta for the period 2018-2019 were obtained directly from NOSDRA. The documented spills record by the different oil companies, for example, Shell Petroleum Development Company (SPDC), Nigerian Agip Oil company (NAOC), Pipeline and Products Marketing Company (PPMC), HERITAGE OIL and CO_2 emission were obtained and calculated. The total volume of oil spills recorded in 2018-2019 was 58845.48 barrels, which was equivalent to 25303.56 and 581981.88 metric tons CO_2/barrels and methane/barrels emissions. Whereas SPDC flow stations contributed the highest volume of spills in Imo, Akwa Ibom, Bayelsa and Rivers, Heritage Oil and PPMC contributed the most substantial volume in Delta and Edo respectively.

Consequently, it can be inferred that the oil and gas industry in the region contributes yearly and substantially to the greenhouse gas emissions within the Niger Delta and nationally. The continuous emission and poor monitoring of greenhouse gases can be attributed to the slow implementation of the country's NDCs contributions within the oil and gas sector.

We are recommending that the flared gas be channelled towards providing energy for households in Nigeria and the Niger Delta in particular. There is a need to enlighten, strictly monitor the oil and gas companies for gas flaring, as well as encourage them to invest in technologies capable of converting it to electricity at a profitable rate, which will in turn, boost the national economy and power deficit in the country. Furthermore, the Federal Government of Nigeria should empower the Department of Climate Change (DCC) in the Federal Ministry of Environment as the frontier agency with the sole responsibility to execute, monitor and evaluate the implementation of the NDCs related to oil and gas industries in Nigeria. Also, the DCC should develop a gradual but sustainable energy transition plan from oil. This will involve stringent guidelines and compensations commensurate to livelihood support for communities affected by the oil spill and gas flaring activities. The government should constantly review and approve the licenses of the oil and gas companies based on their routine facilities check, performance indices, efficient management system, environmental friendliness of operation and corporate social responsibility. This will further help to forestall and/or reduced oil spillages and greenhouse emissions in the region. Finally, there is an urgent need to increase knowledge and awareness on climate change risks and opportunities, to accelerate the implementation of Nigeria's NDCs and achieving Agenda 2030 of the United Nations Sustainable Development Goals (SDG's) especially goal #13, namely climate actions.

CHAPTER ONE

1. INTRODUCTION

Preamble: *This chapter provides useful background information to the study, the purpose of the study, a brief review of the study area and the knowledge gap the study attempts to fill.*

1.1. Background to the Study

Nigeria is actively engaged in international climate policy negotiations. It became party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, ratifying its Kyoto Protocol in 2004. Nigeria submitted its First National Communication (FNC) in 2003 and a Second National Communication in February 2014.

In addition to being a major player, Nigeria has benefitted from some of these international climate protocols, notably the Clean Development Mechanism (CDM) projects and climate projects financed by the Adaptation Fund.

Whereas the Federal Executive Council (FEC) in September 2012 approved the Nigeria Climate Change Policy Response and Strategy, the President of the Federal Republic of Nigeria, Muhammad Buhari on the 26th of November 2015, approved Nigeria's Intended Nationally Determined Contribution (INDC) in line with the Paris agreement in combating climate change. The country has commenced implementing its INDCs in line with the National Climate Change Policy Response Strategy (NCCPRS) and the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN).

Nigeria's NDCs has an ambitious goal of reducing greenhouse gases by 20% unconditionally by reducing Business As Usual (BAU) emissions and 45% with international support (financial, technological and capacity building) by 2030. Nigeria, like other countries, is expected to review and submit its enhanced NDCs and new ambitions to the UNFCCC under the Paris Agreement after five (5) years, with 2020 being the first instance.

In effect, Nigeria's GDP per capita emission, which stood at 2,950 in 2014, was expected to increase to 3,964 by 2030. However, the NDCs key measures were to work towards off-grid solar P.V. of 13GW

(13,000MW), efficient gas generators, 2% per year energy efficiency (30% by 2030), transport shift from car to bus, improve electricity grid, and climate-smart agriculture and reforestation with a target sector of the energy, the oil & gas, agriculture & land use, power and transport sector. That notwithstanding, our major focus in this study is the oil and gas sector to identify, measure improvement, and compliance of the sector. Also, this will help to understand the enforcement of gas flaring restrictions, development of gas-to-power plants at gas flare sites (microgrid), blending 10% by volume of fuel-ethanol with gasoline (E10) and 20% by volume of biodiesel with petroleum diesel (B20) for transportation fuels in its NDCs. As a party to the UNFCCC, Nigeria's commitment to cut greenhouse gases would severely affect its oil-based economy.

The study embraces clean development mechanisms, decarbonisation and reduction of fossil consumption to inevitably benefit the economy in the long run. Bioenergy development could create more employment in rural areas, contribute significantly to foreign exchange savings, and reduce the over-dependence on oil as the primary source of revenue. Furthermore, we consider implementing the Nationally Determined Contributions (NDCs) as key to reducing gas flaring associated with the oil and gas sector, leading to greenhouse gas emissions and climate change.

Gas flaring involves the rapid oxidation of natural gas with the release of gaseous, particulate and heat into the atmosphere (Giwa *et al.,* 2019). The composition and quantity of natural gas flared determine the amount and type of pollutants emitted. In addition to meteorological conditions, flare design and geometry, and combustion variables (Fawole *et al*., 2016; Torres *et al*., 2012), have remained major contributors to global warming and climate change globally. This infamous act is a foremost source of greenhouse gases, precursor gases, volatile organic chemicals (VOCs), polycyclic aromatic hydrocarbon (PAH), particulate matter (PM) and black carbon (Giwa *et al.,*2014; McEwen and Johnson, 2012), to the environment. Over 250 toxins for example, hydrogen sulfide, toluene, benzene, sulphur dioxide, benzapryene, nitrogen dioxides, xylene have been identified with the flaring of Gas (Giwa *et al.,* 2019; ICF, 2006). These pollutants, especially PM and precursor gases emitted, have been reported to have adverse effects on both the environment and human health (Giwa *et al.,* 2014; Yaduma *et al.,* 2013).

According to the Nigerian flare tracker, about 239.9 million Mscf of Gas was flared between January 2018 to December 2018, with the emission of 12.7 and 292.1 million tonnes of carbon dioxide (CO_2) and methane (CH_4) gas respectively, within the Niger Delta region. The flared gas was valued at 839.8 million USD and a power generation potential of 24.0 thousand GWh.

Similarly, in 2019, about 262.5 million Mscf of gas was flared with the emission of 13.9 and 319.7 million tonnes of CO_2 and CH_4Gas, respectively. This flared gas was valued at 918.8 million USD with a power generation potential of 26.3 thousand GWh. This flared gas could have added to the National GDP and electricity generation, thereby increasing the capacity of the national grid.

Climate change as a phenomenon refers to any variations experienced within the earth's atmosphere over a while. These changes could be due to dynamic processes on earth from natural and human activities such as oil exploration, which is still one of the major drivers for climate change through greenhouse gas emissions. It is a global environmental problem which the Niger Delta region and Nigeria are combating at the moment. The issue of climate change has multi-faceted effects leading to several other environmental problems, including ocean warming, sea-level rise, variability in rainfall, increasing temperature, increasing evaporation, biodiversity loss, among others. The aforementioned, both individually and in combination, has given rise to the rising cases of flooding, erosion, droughts, health-related problems, food scarcity/hunger, poverty, migration, communal crises, including the farmers-herdsmen crisis in Nigeria.

1.2. The Study Area

The Niger Delta region of Nigeria comprises nine states including Abia, Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Imo, Rivers and Ondo. Oil exploration occurs in this region with the major oil companies including SPDC, Mobil Oil Producing, Chevron Nig Limited, National Agip Oil Company (NAOC), Heritage oil amongst others being the key players.

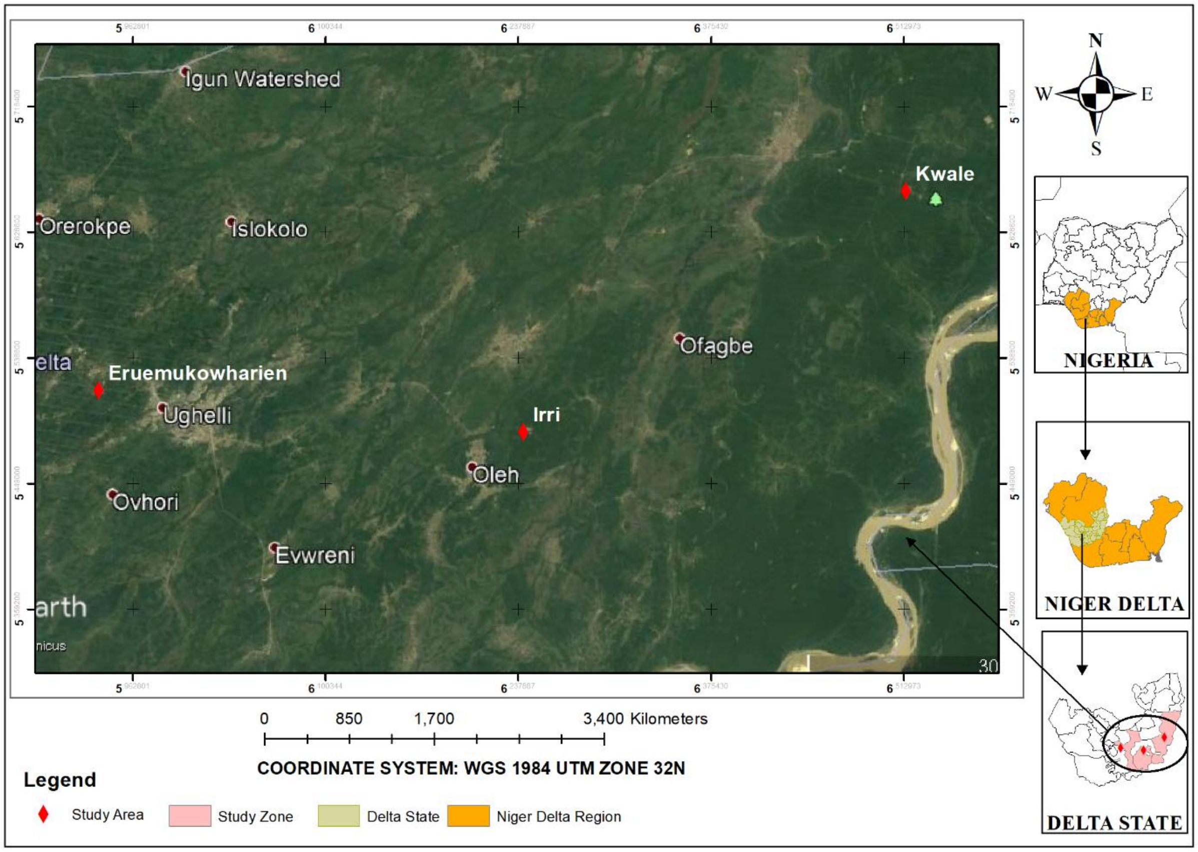


Plate 11.1: Map of Delta state showing the gas flaring/air quality sampling stations (Source: Generated by the SDSNFUPRE study team)

Delta state was selected for this study due to its high crude oil exploration activities. There are more than 123 gas flaring sites in the Niger Delta, with Delta State having the second-highest gas flaring site, partly because most of the oil and gas industries are located in the state. Most of the oil companies release unwanted gas into the atmosphere via the flare stack. These gases are known to be key drivers of climate change. As a result, three (3) flare sites were considered based on high oil exploration activities and the triangular method of spatial sampling to take a representative coverage of the air atmosphere in Delta State within the onshore areas. The sampling stations were at Eruemukowharien, Irri, and Kwale, as shown in **Plate 1.1**.

Over the years, oil companies have helped to improve the lives of people within their respective host communities (via community development projects such as borehole construction, electrical power supply, employment of indigenous labour, building schools and other rural development programmes). Nevertheless, their operational activities have impacted negatively on the host communities, from crude oil spillage, gas flaring, and effluent discharges mismanagement. The aforementioned is not strange, for there are several documented reports and researches on the menace of oil activities on land, water and air quality of host communities. Therefore, continuous assessment of the quality of life in the region with regards to the air, water and land environment is required.

1.3 Aims and Objectives

The overall aim of the present study is to examine the compliance practices of the oil and gas companies in Nigeria's Niger Delta geared towards the implementation of the Paris Agreement and reduction of greenhouse gas emissions in Nigeria's Nationally Determined Contributions (NDCs).

The following objectives will ensure that the aim of this study is achieved:

1. Identification of threat to climate change posed by the oil and gas industry within the Niger Delta region.
2. Proffer solutions to reducing greenhouse gases emissions by oil and gas companies in Nigeria.
3. The current status of implementation of Nigeria's Nationally Determined Contributions (NDCs) to the Paris Agreement and compliance level.

1.4. Literature review

The oil-producing companies in the region are often involved in the flaring of gases with the notion that the air is an "inert continuum." Their modes of gas flaring are either by ground or stack flaring. The flared gases contain NOx, SOx, CO, CO_2, CH_4, lower hydrocarbons, volatile organic carbons(VOCs), benzene, CFCs, and so on. The FEPA report of 1998 and UNDP/World Bank 2004 stated that gas flaring in the Niger Delta could release up to 35 million tonnes of CO_2 every year (Abdulkareem *et al*., 2012). EPA (2017) stated that 25,000 metric tons of CO_2e were released from petroleum and natural gas system, which means that all petroleum refineries, exporters and importer of petroleum products and natural gas liquids from oil companies whose supplied products would result in 25,000 metric tons of CO_2e or more per year if the products were fully combusted. These gases react with atmospheric gases both to change and increase the natural concentration in the atmosphere. The effect leads to acid rain, climate change, ozone layer depletion and global warming. Also, during the flaring, the environment is heated up through heat radiation, which has adversely affected human lives, flora and fauna in about 500m circumference distance around the flaring station. On the contrary, there are unsubstantiated claims within these communities that the radiation could heal patients with arthritis when they get close to the ground flare stations.

The released acidic gases combine with the moisture content of the air to form acid rain. This rain destroys buildings architectural designs, and paints are corroded. It could also increase the acidic content of the rivers, constitute a nuisance to life underwater and on land.

Climate change interplay with the atmosphere blocks the direct radiation of the sun from reaching the earth, thereby acting as a greenhouse barrier. When these flared gases react with the atmosphere, especially the CO_2, they attract the solar heat, which increases the temperature and adversely affect life on the earth and water (Abdulkareem *et al*., 2012).

Odigure *et al.,* (2003) reported that people living around gas flaring stations are prone to health risks, including cardiac arrest, paralysis and associated ailments due to constant exposure to heat radiation. In recent times, there was a loud cry in Port Harcourt, Rivers state Nigeria about the clouding of the environment with particulate soot. When cars are parked, there is condensed soot all around the vehicle after a period. Such a situation was also observed in Warri city, Nigeria, even in non-oil producing communities. Some gas flaring pieces of evidence are the soot and carbon black emanating from low viscosity crude carried with flare. The condensed particulates may also contain polynuclear aromatic hydrocarbons (PAHs), and other trace metals (Agbo, 1997). The particulate matter and soot can be easily inhaled, leading to cardiovascular and respiratory tract diseases or cancer of the lungs (Nelin *et al*., 2011; Olaguer, 2017; Li *et al*., 2018).

Oil spillage is another route through which obnoxious gases are released into the environment. Oil spillage could be by indiscriminate activities and operations of the oil companies or inadvertent tampering of oil pipelines by miscreants for selfish economic reasons. These activities release the oil into the environment, flowing into the water bodies and releasing methane (CH_4), CO_2, and other lighter hydrocarbons into the air. Nwachukwu and Osuagwu (2014) carried a study on the effect of oil pollution on groundwater. They concluded that the groundwater of the study area was contaminated due to oil spillage, which may have a corresponding and adverse effect on indigenous people, consuming the waters and a previous health history. Onwurah (as cited in Chukwuka *et al*., 2018) concluded that exposure to low-boiling saturated hydrocarbons (gasoline range), at low concentrations, produces anaesthesia and narcosis while at greater concentration, may lead to cell damage and death in a wide variety of soil invertebrates and lower vertebrates. Zabbey (2004) agrees with the data collected from the NOSDRA site that indicated that most oil spills or leakages from oil and gas companies occur in the mangrove swamp forest.

Consequently, the water around mangroves, sediment, mangrove leaves, pneumatophores, and roots have been reported to be sensitive to oil fractions (Diab and Bolus, 2014). Oil films or coating on the water surface limit slight penetration and the free exchange of oxygen between water and air. It could reduce the dissolved oxygen in the water body leading to the death of aquatic life forms present. Oil exploitation in the Niger Delta of Nigeria has increased deforestation and will consequently increase the number of greenhouse gases (CO2) and decrease the amount of oxygen (O_2) present in the atmosphere.

Oghenejoboh *et al. (*1970), have investigated the air quality around four SPDC flow stations flare stacks at Afiesere, Utorogu, Evwreni and Eriemu, Delta state. Their reports showed low concentrations of SOx, H_2S and NOx gases but high ozone. High CO, volatile organic compounds (VOC) and particulates were recorded in Utorogu and Ewreni fields only.

Mbaneme *et al.* (2014), also investigated the ambient air quality of Obrikom flare station in Rivers State and found out that all the detected gases (CO, SOx, NOx, H_2S, O_3), suspended particulate matter (SPM), volatile organic compounds (VOC) and heavy metals are below the DPR recommended limits for a safe environment.

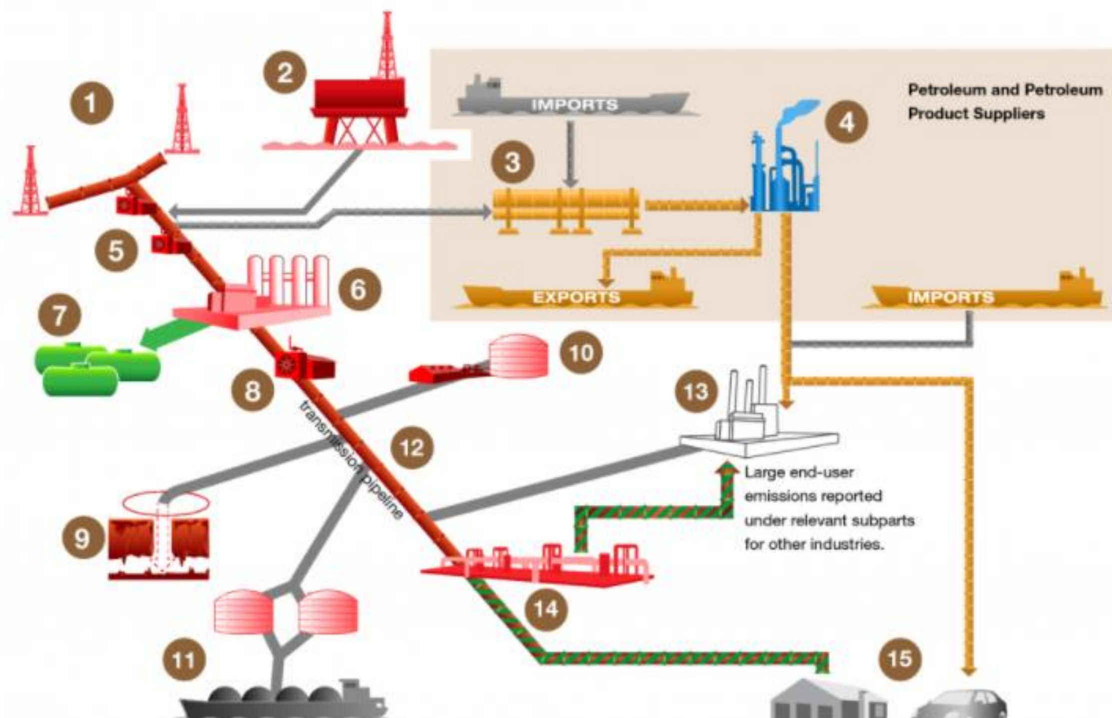
Ibe *et al.*, (2015) carried out an air quality assessment in Orlu, which is close to the Ohaji/Egbema/Oguta area of Imo State, which is away from gas flaring stations. Their results showed a high level of greenhouse gases in some of the study locations and above the Nigerian National Ambient Air Quality Standards Nigerian (NAAQS) and the United States National Ambient Air Quality Standards (US NAAQS) because of the release of gases from the oil and gas industry within the nearby communities of Ohaji/Egbema/Oguta.

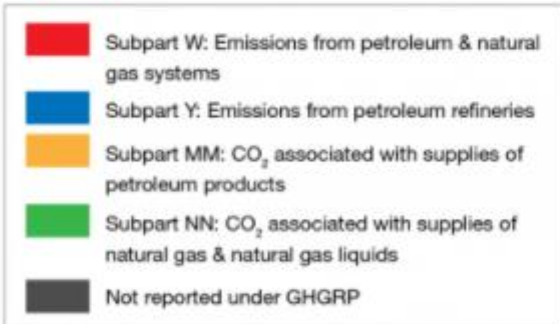
These gases were possibly transported by wind from the numerous gas flaring stations around to the air environment of the Orlu community. The gases were comprised of greenhouse gases such as methane (CH_4), carbon monoxide (CO), Sulphur Oxides (SOx), Nitrogen oxides (NOx) and Hydrogen sulphide (H_2S).

The health implication of air pollution cannot be over emphasised. There is no doubt that oil exploration activities in the Niger Delta have improved Nigeria's economy at large but to the detriment of the environment and human health safety. Colombo *et al*., (2015) reported that about 134 billion m^3 of associated gas got flared or burned in 2010. If this practice, which is an absolute waste of energy, is curbed, it could amount to electricity generation through combined cycle turbo gas, which would add more megawatts of energy to the national grid. Although, there could be arguments that the different impurities or contaminants in the flared gases could hinder the consideration of channelling towards energy generation because it could damage the engineering or combustion device since it is an oxidation process. Nevertheless, the report has shown that a prototype “Power Oxidiser,” that can accumulate low-quality gas, undertake oxidation reaction within a short period and release heat energy capable of powering a turbine or boiler has been developed.

Aregbe (2017) is of the view that there are different alternatives to gas flaring. The suggestions are that instead of flaring the gases, they could serve as a source of energy and feedstock for the petrochemical plants. Also, these gases can be reinjected for secondary oil recovery, clean electricity production, especially for their host communities suffering from electricity.

Plate 11.2: A typical flare site in the Niger Delta region (SDSNFUPRE fieldwork picture)





Subpart W: Emissions are 25,000 metric tons CO2e or more per year from a facility
Subpart Y: all petroleum refineries
Subpart MM: all petroleum refineries, exporters and importer of petroleum products and natural gas liquids whose supplied products would result in 25,000 metric tons CO2e or more per year if the products were fully combusted
Subpart N.N.: all fractionators of natural gas liquids and natural gas distribution companies that deliver 460,000 Mscf or more of natural gas per year.

Fig.1. 1. Emissions sources from different sections of oil and gas companies operations (EPA, 2017)

A	**Production and Processing :** 1. Onshore Petroleum &Natural Gas 2. Offshore petroleum & Natural gas production 3. Total crude oil to refineries 4. Petroleum refining 5. Gathering and Boosting 6. Gas processing plant 7. Natural Gas Liquids (NGL) supply
B	**Natural Gas transmission and storage** 1. Transmission compressor stations 2. Underground storage 3. Liquid Natural Gas (LNG) storage 4. LNG Import-Export Equipment 5. Natural Gas transmission pipeline
C	**Distribution** 1. Large End Users 2. Natural Gas Distribution 3. Natural Gas and Petroleum Supply to Small End Users

CHAPTER TWO

2.0. METHODOLOGY

Preamble: *This chapter details the methodologies employed to achieve the aim of the study. It presented the parameters such as smoke density, wind speed, noise level, ambient air quality and others investigated and calculated, to determine the greenhouse gas emission from oil and gas companies in the Niger Delta region. Also, the information on limits and guidelines governing each parameter were discussed in this chapter.*

2.1 Introduction

This field study report on Eruemukowhareie, Irri and Kwale oil locations, as shown in Figure 1.1. The data were taken and analysed in triplicates to ensure the precision of the equipment and accuracy. Meteorological parameters such as temperature (^oC), Wind Direction, Wind Speed (m/s), Relative Humidity (%) and Pressure (mmHg) are essential climate information obtained from the best location to gather maximum data during field study/air analysis. The observed results were compared with the Nigerian ambient air quality standards (NAAQS) in Table 2.1 and Table 2.2.

2.2. Smoke Density

A graduated Ringelmann chart (B.S.2742M) was used to determine the smoke density of the flares. The chart is numbered from 0-4, with 0 being the lowest density, while four is the highest. The A graduated Ringelmann chart was held at about 20 meters from the flares to examine and compare the smoke coming out with the chat.

2.3. Ambient temperature, Wind Speed, and direction

The wind speed, ambient temperature, atmospheric pressure and relative humidity were measured using WindMate (WM350). The direction of the wind was noted with an in-built wind vane and compass.

2.4. Ambient Air Quality

The ambient Air Quality was determined with different equipment. Aeroqual Gas Monitor (500 Series) was used to measure NO_2, SO_2, CO, VOC and O_3 while Met One Particulate Counter was used to measure the Suspended Particulate Matter (SPM). The air quality sampling was carried out at about 50 to 60 metres from the selected flare sites of oil companies in the Niger Delta region.

2.5. Noise Level

The noise level was measured using Extech Sound Level Meter calibrated to 94.0dB(A).

AIR QUALITY STANDARDS

Table 2.1: Nigerian Ambient Air Quality Standard (Uduak, O.L., 2014)

Pollutants	Time of Average	Limit
Particulates	The daily average of hourly values Hourly value	250µg/m^3 600*µg/m^3
SO_x as SO_2	The daily average of hourly values Hourly value	0.01ppm (26µg/m^3) 0.1ppm (260µg/m^3)
NO_x as NO_2	The daily average of hourly values (range)	0.04 – 0.06ppm (75-113µg/m^3)
Carbon Monoxide	Daily average of hourly values 8 - hourly range	10ppm (11.4mg/m^3) 20ppm (22.8mg/m^3)
Petrochemical Oxidants	Hourly value	0.66ppm
Non-Methane Hydrocarbon (VOC)	The daily average of 3-hourly values	160µg/m^3

*Note: Concentration not to be exceeded for more than once a year (Uduak, O.L., 2014)

Table 2.2: WHO Air Quality Guidelines (Uduak, O.L., 2014)

Pollutants	Time- Weighted Average	Averaging time
SO_2	500	10min
	300	1h
	100 - 150[b]	24h
	40 - 60[b]	1yr
CO	30	1h
	10	8h
NO_2	400	1h
	150	24h
O_3	150 - 200	1h
	100 – 120	8h
Black smoke	100 - 150	24hr
	40 - 60[b]	1yr
Total suspended particulates	150 - 230[b]	24hr
	60 - 90[b]	1yr
Thoracic particles (PM_{10})	70[b]	24hr
Pb	0.5 – 1	1yr

[a]All concentrations in µgm^{-3} except for C.O.in mgm^{-3}

[b]Guideline values for combined exposure to SO_2 and suspended particulate matter (they may not apply to situations where only one of the components is present)

CHAPTER THREE

1. Introduction

***Preamble**: This chapter presents the result of the field observation and study data obtained to achieve the aims and objectives of the study. Important data were collated, analysed and compared with the DPR and FMENV regulatory limits for the investigated parameters, to determine the emission and compliance level of these companies.*

1. Results

The field studies revealed the results of the ambient air temperatures, relative humidity, pressure, smoke density, noise level, VOCs, CO, SO_X, NO_x, O_3, and SPM as shown in Table 3.1 and 3.2 and graphically represented in Figure 3.1 and 3.2.

Table 3.1: Meteorological parameters at the sampling stations

Location	Date	Temp. ºC	Wind Direction	Wind Speed (m/s)	Relative humidity (%)	Pressure (mmHg)
Eruemukowhareien Study 1	1/12/19	34.8	NE	2.4	61.2	756.8
Eruemukowhareien Study 2	5/12/19	35.8	NW	3.2	44.7	757
Eruemukowhareien Study 3	13/12/19	36	NE	2.1	30.7	755.7
Eruemukowhareien Study 4	17/12/19	36.7	NE	1.8	41.7	756.2
Irri Study 1	5/12/ 19	32.9	SW	1.1	40.1	756.4
Irri Study 2	13/12/19	30.4	SW	0.8	49.7	755.7
Irri Study 3	17/12/19	36.2	NW	2.3	38.1	753.6
Irri Study 4	20/12/19	34.7	SW	1.8	41.8	754.5
Kwale Study 1	05/12/19	33.9	SE	0.9	58.2	757.6
Kwale Study 2	13/12/19	30.8	SW	0.5	48.1	755.4
Kwale Study 3	17/12/19	34.1	NW	1.4	38.2	756.1
Kwale Study 4	20/12/19	36.4	SE	0.4	32.7	754.9
Average		34.39	-	1.56	43.77	755.83
Range		30.4 - 36.7	-	0.4 - 3.2	30.7 - 61.2	753.6 - 757.6
FMENV Limits		35	NS	NS	NS	NS
DPR Limits		NS	NS	NS	NS	NS

NS = Not Stated

Source: SDSN field study, *2019*Table 3.2: Air Quality /Noise Level Field Measurement in the Study Areas

Location	Date	CO (ppm)	VOC (ppm)	NOx (ppm)	SOx (ppm)	O_3 (ppm)	PM 10 (μg/m³)	Smoke Density	Noise (dB(A))
Eruemukowhareien Study 1	01/12/19	2.2	4	0.027	<0.01	<0.001	9	2	61.2
Eruemukowhareien Study 2	05/12/19	1.2	5	0.034	<0.01	0.001	14	3	44.7
Eruemukowhareien Study 3	13/12/19	<0.1	2	0.018	<0.01	<0.001	21	2	30.7
Eruemukowhareien Study 4	17/12/19	2.8	7	0.049	<0.01	<0.001	22	1	41.7
Irri Study 1	05/12/19	1.3	3	0.019	<0.01	<0.001	17	1	40.1
Irri Study 2	13/12/19	<0.1	6	0.041	<0.01	<0.001	24	1	49.7
Irri Study 3	17/12/19	1.2	4	0.032	<0.01	<0.001	24	2	38.1
Irri Study 4	20/12/19	0.9	5	0.043	<0.01	<0.001	38	1	41.8
Kwale Study 1	05/12/19	<0.1	6	0.041	<0.01	<0.001	20	3	58.2
Kwale Study 2	13/12/19	1.4	5	0.029	<0.01	<0.001	17	2	48.1
Kwale Study 3	17/12/19	0.8	8	0.023	<0.01	<0.001	28	2	38.2
Kwale Study 4	20/12/19	4.9	4	0.049	<0.01	<0.001	33	3	32.7
Average		1.46	4.92	0.034	-	-	22.25	1.92	59.33
Range		<0.1 - 4.9	3.0 - 8.0	0.018 - 0.049	-	-	9.0 - 38	1.0 - 3.0	51.4 - 75.3
FMENV Limits		10	160	0.04-0.06	0.1	NS	250	NS	90
DPR Limits		0.01	NS	0.08	0.4-0.6	NS	60-90	2	90

NS = Not Stated

Source: SDSNFUPRE field study*, 2019*

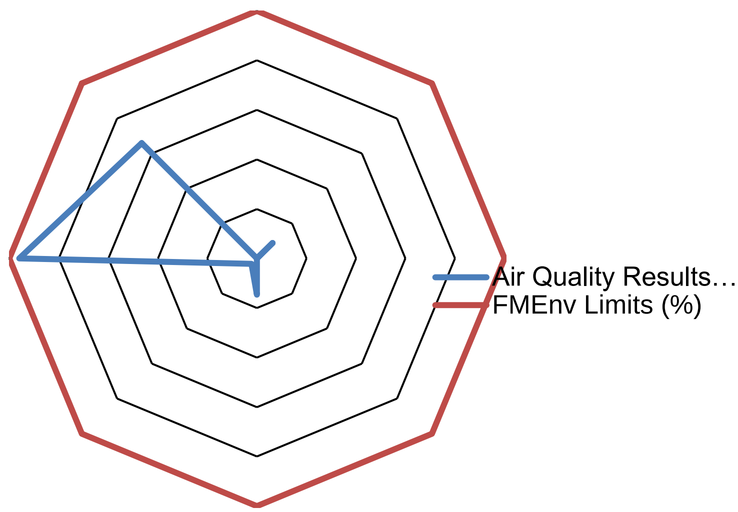


Figure 3.1: Fieldwork results in compliance with DPR and FMENV Air quality limits (%). (SDSNFUPRE study team)

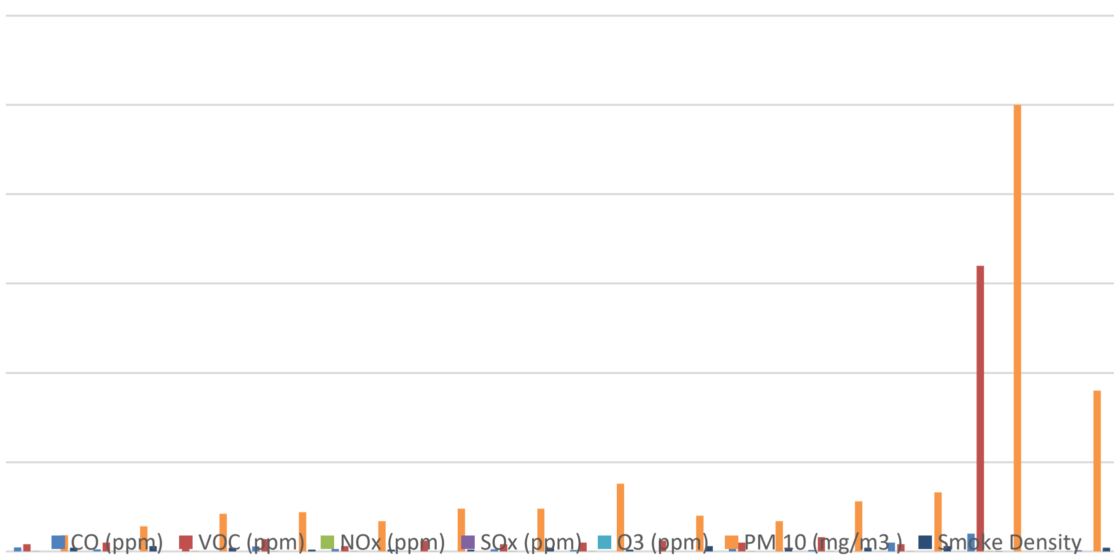


Fig. 3.2: Results of fieldwork compliance with DPR and FMENV Air quality limits (%)(SDSNFUPRE study team)

3.2. Field observations

During the field studies, the following were observed:

1. The filter in some of the gun barrels and other separation units were aged and needed to be changed. While some have not been changed many years after installation, others have been in use for 10 to 20 years now. This further makes it difficult to separate crude oil from its associated gas and its associated water component. When the gas is not entirely separated, it may result in increased smoke density and gas flaring.
2. The ambient temperature of the environment may also contribute to irregular smoke density. With higher temperatures, the flare smoke density will be high due to the increased temperature of the gas - flared. Some of the crude oil escape through the separation processes with the gas as it becomes lighter and consequently transported for flaring. During the burning process, the escaped crude finds it challenging to undergo complete combustion. This may also contribute to the high smoke density observed.
3. There were lots of daily venting of excess gas into the atmosphere. These gases may contain a high amount of methane (CH_4) and other associated gases. These gases are vented more in gas plants than the regular flow stations. Methane is among the greenhouse gases, which may further result in global warming and ozone layer depletion.
4. During sampling, some of the major constituents of the gas flaring smoke were not captured due to the height of the gas flaring stack above the ground level. The gases are light in weight and move easily upwards with the predominant wind and direction.
5. Also, around some of the flare sites, local people use the heat to dry food items (**Plate 3.1 a&b**) such as fish, meat, tapioca or kokpo garri (a crunchy snack made from cassava root), ground-nuts. This could inform future research investigation to ascertain the human health implications from their (food) consumption.

Generally, most oil and gas facilities have an API unit used to temporarily store excess crude in their system. The API unit is usually constructed like an open pit, leaving the surface of the crude oil exposed and it can result in the escape of volatile organic compounds (VOC) from the API unit into the immediate environment**.**

a 

Plate3.1ab: Villagers using the heat of the gas flaring to dry produces (Source: SDSNFUPRE team)

CHAPTER FOUR

4.0. DISCUSSION

Preamble: This chapter discusses the results in chapter three of the study, including the meteorological parameters of the study area. The theoretical calculation of the greenhouse gas emissions of the oil and gas companies in the Niger Delta is based on the data provided by NOSDRA, to estimate the impact of the operational activities on the levels of greenhouse gases in each of the Niger Delta States.

4.1 Meteorology of the study area

The field measured air temperature ranges between 30.4^oC and 36.7^oC. The air temperatures in the study area were generally high, and it largely depends on the wind speed and wind direction.

The relative humidity represents the quantity of water vapour contained in the atmosphere. It is the quantitative expression of wetness or dryness (in percentage) of the air. During field sampling, it was observed that relative humidly values mainly were below 50%, primarily as the Niger Delta region is known to experience a lower amount of water vapour due to the dry season. The study measured relative humidity ranging from 30.7% to 61.2%.

The north-easterly (N.E.) wind was the dominant wind direction in the study area with lower moisture-bearing low wind speed accompanied by loads of dust. However, the wind speed was in the range of 0.4-3.2 m/s.

4.2 Air Quality/Noise Level at the sampling sites

The results of the air quality measurements for the selected study areas (Table 3.1) showed that PM 10 ($\mu g/m^3$) concentrations in the ambient air ranged between 9.0 and 38.0$\mu g/m^3$. The mean concentration recorded was within the Nigerian ambient air quality standards (NAAQS) of 250$\mu g/m^3$ (daily average of hourly values) and 600$\mu g/m^3$ (concentration not to be exceeded for more than once a year) (FEPA, 1991).

NO_x concentrations ranged from 0.018 - 0.049ppm, while that of CO ranged from <0.1 - 4.9ppm, VOC was between 3.0 - 8.0ppm, while SO_x and O_3 concentrations in the study areas were below the equipment detection limit of <0.01 and <0.001ppm, respectively. The concentrations of the above-stated parameters were within permissible limits of the FMENV, and DPR EGASPIN (2018) allowable limits (Figure 4.1). The smoke density ranged from 1-3 on the ringelmann smoke chart, that is, the smoke density moved from being 100% light transmission through the smoke to 40% less light transmission. However, about 25% of the smoke density result was above the DPR EGASPIN (2018) permissible limit of 2, while 41.7% at the benchmark (2).

Furthermore, the study showed that the smoke density might have a corresponding effect on the climatic condition of the Niger Delta region, it is not 100% light transmission through the smoke. The smoke density has the potentials of travelling in the prevailing wind direction. In its course of movement, it may settle down on vegetation, thereby blocking the stomata and further reducing the rate of plant photosynthesis. When this happens, it reduces the ability of green vegetation to absorb carbon dioxide directly from the atmosphere and consequently, more CO_2 in the atmosphere.

This will in turn, undergo further photochemical reactions with the available CO_2 -- contribute significantly to ozone layer depletion, global warming and climate change. Similarly, the presence of NOx (a constituent of greenhouse gases), when it enters the atmosphere, could be transformed into nitric acid (HNO_3), which could further react with HCl, and generate acidic precipitation, known as acid rain.

The study areas result in ambient noise level (presented in Table 3.2) ranges from 51.4 to 75.3dB(A) with an average of 59.33 dB(A), which was lower than the permissible noise level of 90 dB (A) for an 8-hour working period recommended by FMENV and EGASPIN. Although the values of the measurement of most gases seem lower than expected because they are light and moved upward, the impact of the contributions of the gas flaring could be observed through the deposit of soot and acid rain. The latter (acid rain) has five serious effects on the Niger Delta environment such as:

1. Degradation of soil: sensitive soil microorganisms that cannot adapt to the acid rain pH will be killed and soil microbes enzymes at the same time denatured. It can still leach away vital nutrient and minerals in the soil. Thus, the soil loses its capacity to support plant life and microorganisms.
2. Damage to trees and vegetations: Acid rain dissolves the most vital nutrient needed by trees to survive. It causes the discharge of vast quantities of aluminium into the soil around the trees and renders them incapable of absorbing water. Consequently, the vegetations and trees become vulnerable to disease and pest attack, stunted growth and death -- contribute to the deforestation rate, especially mangroves in some part of the Niger Delta. This is in addition to natural vegetation losses occasioned by fire outbreaks under high atmospheric temperature in the most poorly remediated oil spill site.

3. Effect on aquatic life form: pH has a significant impact on the aquatic life form. When the pH of water is below 5, most fish eggs cannot hatch, and it can also kill adult fish. High acidity causes unbearable survival circumstances, which has reduced or even killed species among the biodiversity of the aquatic ecosystem.
4. Human health implication: Humans are not left out on the devastating impact of GHG with the mild effect of headaches, irritations of the nose, throat and eyes. At critical levels, heart and lung-related health problems have been unavoidably linked to GHG formation of acidic deposits.6
5. Corrosive effect: The release of GHG causes acid rain with damaging corrosive effects on metals, building and car paints, marbles, limestones used for building structures, gravestones, statues and other historic monuments in Niger Delta.

4.3. Theoretical calculation of greenhouse gases from oil spills around the Niger Delta Region

The carbon dioxide and other infrared-absorbing gases have been established as a significant contributor to global warming because they allow incoming solar radiant energy to penetrate to the earth's surface while reabsorbing infrared radiation emanating from it (Kweku *et al*., 2017). Although methane is 20 – 30 times more effective in trapping heat than carbon dioxide on a molecule-for-molecule basis, carbon dioxide is the gas most commonly thought of as a greenhouse gas. Carbon dioxide contributes to about half of atmospheric heat retained by trace gases. The carbon dioxide molecule absorbs infrared radiation and starts vibrating. The vibrating molecules emit the radiation again before reabsorption by another greenhouse gas molecule. The cycle of absorption-emission-absorption keeps the atmosphere heated and effectively insulates the earth from the cold outer space (Kweku *et al.,* 2017).

Greenhouse gas reporting program by USEPA cover emissions from different aspects of the oil and gas industry such as extraction, production, transport, and use as shown in Fig. 1.1 and listed of label numbers on the pictorial flow diagram (EPA, 2017):

This report only considered data collected during field studies in addition to data obtained from the National Oil Spill and Detection Response Agency (NOSDRA). From the study results, as shown below (**See plate 4.2**), it is evident that most spills occur during explorations, burnouts, vandalisation of pipeline and illegal modular refineries activities scattered around the Niger Delta (**See plate 4.1**), which may have contributed to colossal greenhouse gases emissions.

Plate 4.1: Major oil spills within the Niger Delta region for 2018 and 2019 (SDSNFUPREstudy team).

Plate 4.2: Spill impact on 14 "Okordia Rumuekpe Pipeline at Akalamini. The picture was taken during the Joint Investigation of 25 February 2020. (Source: SPDC Oil Spill Data, 2020)

It is essential to know that the present study had few limitations in measuring the aerial release of greenhouse gases. Especially in the gas flaring sites, most flare stack typically ranged between 10 to 60 meters in height above ground level. This great height allows for quick movement of the light hydrocarbon gas compounds upwards and is also capable of travelling long distance before returning to the earth's surfaces as either carbon soot or in precipitation as acid rain. Research by some students of the Federal University of Petroleum Resources Effurun, Delta state, recorded high concentrations of carbon soot in the atmosphere, which may have not only originated from crude oil activities (Okorhi-Damisa et al., 2020).

This significantly corroborates the results of related researches on air pollutions within the Niger Delta region. Under the Nigerian laws through the Environmental Guidelines and Standards for The Petroleum Industry in Nigeria (EGASPIN), issued by the Department of Petroleum Resources (DPR) permit these oil and gas companies to flare gases. The EGASPIN-DPR Act as amended in 2018 stipulated a Polluter Pays Principle for Oil and Gas companies to pay an estimated amount for flaring and clean-up oil spills resulting from their activities. An amount the host communities and environmental right activists considers not commensurate to the damages to the environment.

Additionally, the producers and permit holders (P.H.) of gas flaring is prohibited from flaring and venting gas from any facility or greenfield project without an approval/permit issued by the Honourable Minister/Director. The Flare Gas payment of USD 2.0 per 1000 Standard Cubic Feet (*scf*) was increased significantly. A production-based method of calculating the flares payment have been proposed, which provide that if 10,000 barrels of crude oil or more are produced per day in an Oil Mining Lease (OML) area or any field designated as a marginal Field (M.F.), the producer shall be liable to pay USD2 per 28.317 *scf* of gas flared within such OML area or M.F., irrespective of whether the flaring is routine or non-routine. However, if crude oil production is less than 10,000 barrels of oil per day, the Producer and P.H. shall be liable to a flare payment of US$0.50 per 28.317*scf* of gas flared in the OML area or M.F.

Furthermore, the regulation stipulates that if a Producer fails to prepare, maintain, or submit logs or records, or reports or install metering equipment, amongst others, the producer shall be liable

to pay an additional sum of $2.50 per 28.317 *scf* of gas flared or vented within the OML or M.F. In the event of the continued failure of the producer to comply with the operational requirements in the regulations, the Minister may suspend the operations of the producer or revoke the OML/MF license.

However, there are other possible sources of greenhouse gases to the atmosphere, such as wastewater treatment plants (Kweku *et al.,* 2017), household generators, and vehicular emissions. These emissions may be due to the incomplete combustion of fuels by some engines. They were not considered within the scope of this investigation, as they may not be directly under the oil and gas industry.

The examination of possible greenhouse emissions from spills around the Niger Delta was considered because it has been a constant event across the region. The USEPA energy and environment section on climate change and greenhouse gases discussed the calculation on global warming potentials from the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (EPA, 2017).

For a barrel of oil, carbon dioxide emissions can be obtained thus:

Metric tons of CO_2 = 5.80mmbtu X 20.31 kgC/mmbtu X 44kgCO_2/12kgC X 1 metric ton /1000kg (EPA, 2019 and IPCC, 2006). The value obtained from the formular thus is 0.43 metric tons of CO_2/barrel (EPA, 2019).

The metric tons CO_2/barrel equivalent gives the estimated quantities of CO_2 released into the atmosphere before the clean-up at locations within the Niger Delta region. The results were presented based on potential contributions to Niger Delta by all Oil and gas companies, potential contributions per State in Niger Delta.

Methane is 28 times the global warming potential of carbon dioxide value, which means methane will have much more impact than carbon dioxide when considering heat absorption.

1. Oil and gas companies contributions to CO_2 emission within the Niger Delta

The names of the operating oil and gas companies in the Niger Delta are revealed in the figure below. The total spills recorded in the Niger Delta for the year 2018 to 2019 is 25924.45 barrels, which is equivalent to 11147.51 metric tons CO_2/barrels emissions. The figure shows that NAOC, SPDC, Heritage, Eroton E & P, Alteo E&P and NDWEST are potential significant polluters of the Niger Delta environment with consequential emission of greenhouse gases.

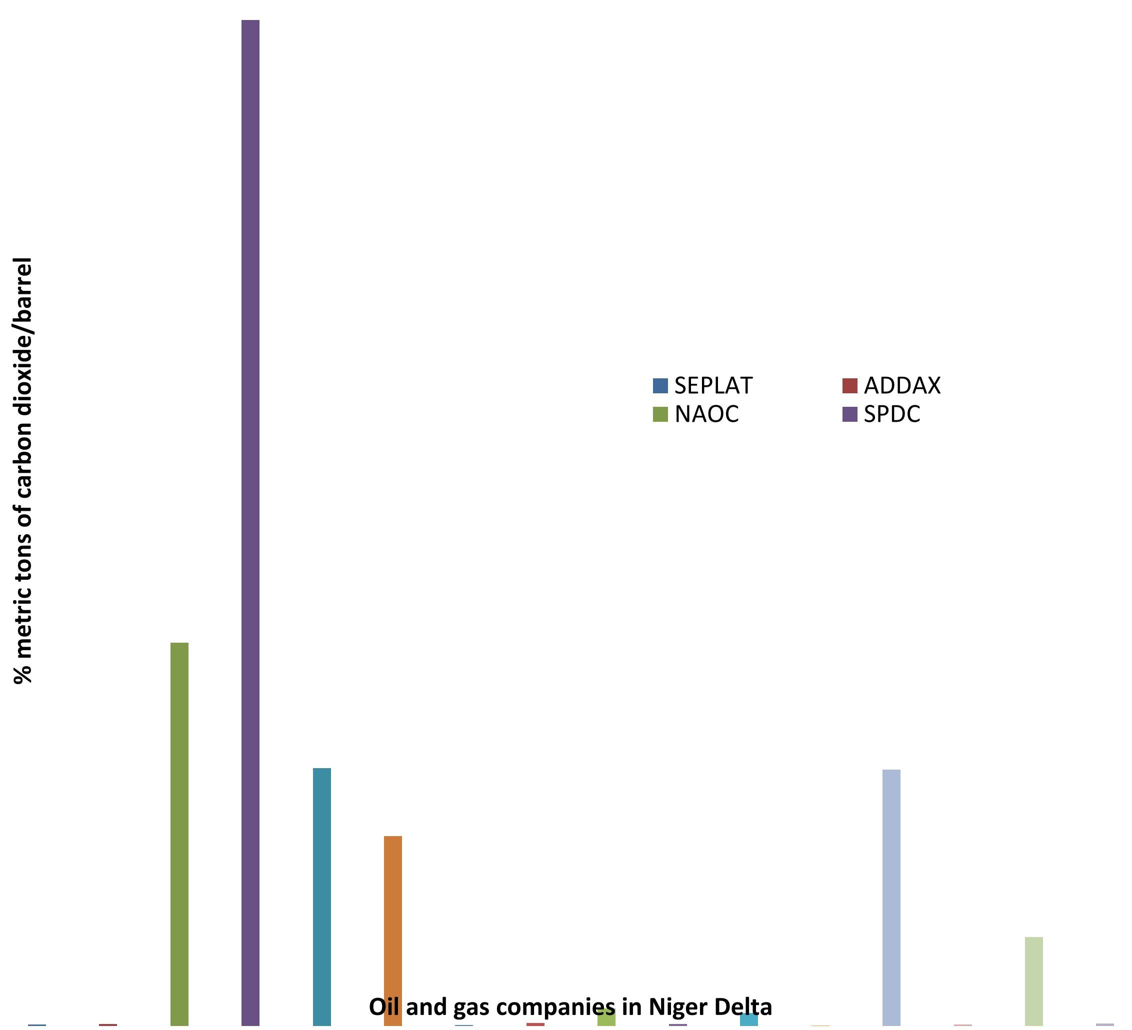


Figure 4.1: Percentage contribution of CO_2/barrel emissions on oil spills in Niger Delta Nigeria. (Source: www.nosdra.gov.ng)

SPDC is the most significant potential contributor of greenhouse gas with 45.3 %, followed by NAOC with 17.2 %, Heritage and Aiteo E&P contributed a similar likely equivalent of 11%, respectively, while the least potential contributor was N.D.Western Limited (NDWEST) among the significant contributors revealed in Figure 4.1. Others have meagre potential to contribute to the greenhouse gases at the regional level. The regional contributions will undermine the impact at the state level to address the seriousness of the need to abate the frequent spillages into the environment and curb the increasing climate change effects.

1. Potential greenhouse gas emission contributions per companies in Edo State

According to the record of NOSDRA on spillages in Edo state, seven (7) major oil companies are operating in the state, but the highest potential contributor of greenhouse gases is PPMC and slight contributions from ERL with less significant contributions from others as shown in Figure 4.2.

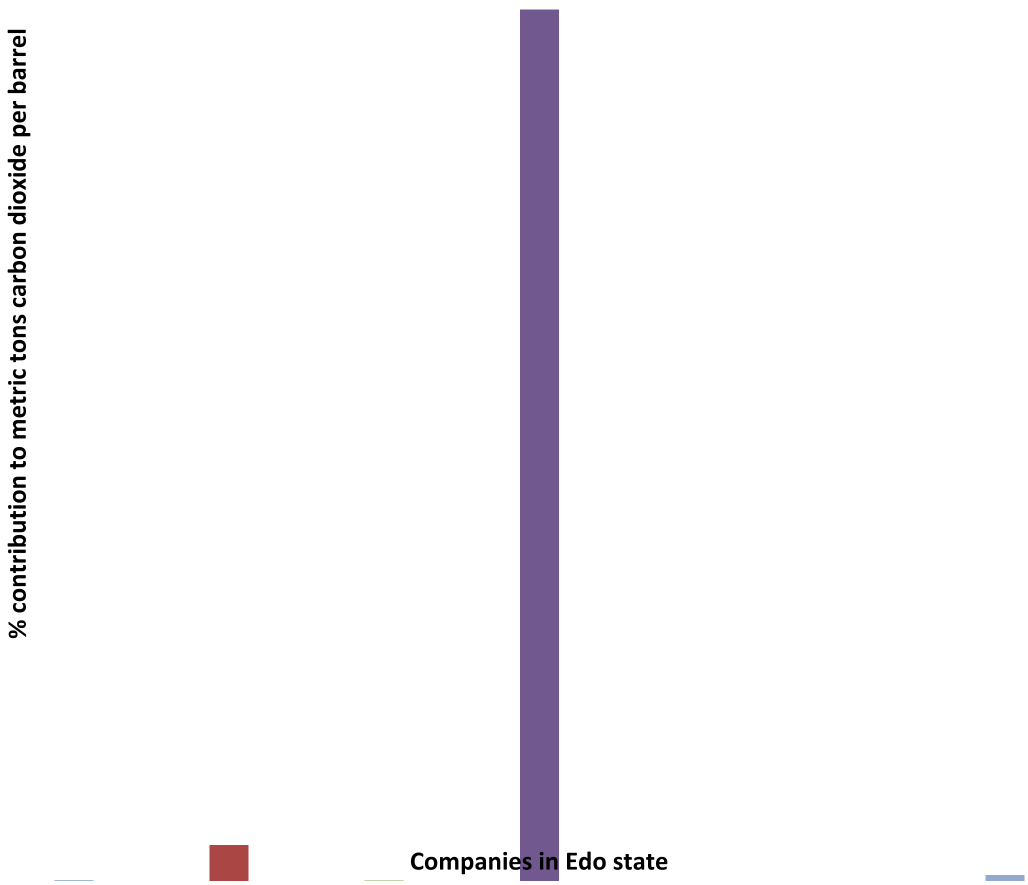


Figure 4.2: Percentage contribution of CO_2/barrel emissions on oil spills in Edo State Nigeria (Source: NOSDRA website)

2. Potential greenhouse gas emission contributions per companies in Rivers State

In Rivers State, SPDC and Aiteo E & P have significant potential contributions of 39.7 % and 32.7 % to the total metric tons of CO_2 per barrel shown in Figure 4.3.

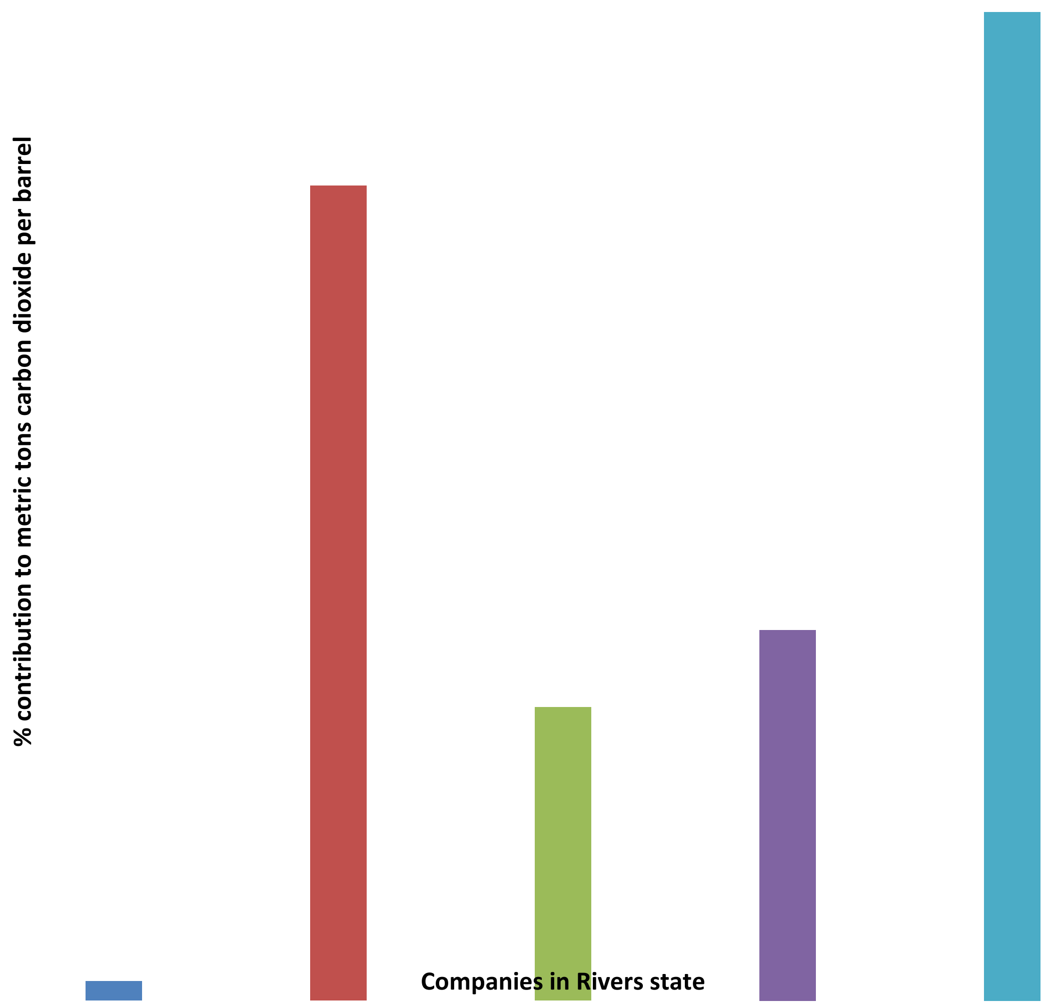


Figure 4.3: Percentage contribution of CO_2/barrel emissions on oil spills in Rivers State Nigeria (www.nosdra.gov.ng)

3. Potential greenhouse gas emission contributions per companies in Delta State

Delta state is the home of all the companies in Niger Delta because they all have a presence in different parts of the State. The calculation of the metric tons of CO_2/barrel in Figure 4.4 shows that Heritage had the highest percentage of 57 %, NDWEST with 21.8 %, while POOCN, SEPLAT, SEEPCO, DUBRI, WRPC, and NAOC contributions are insignificant in the state.

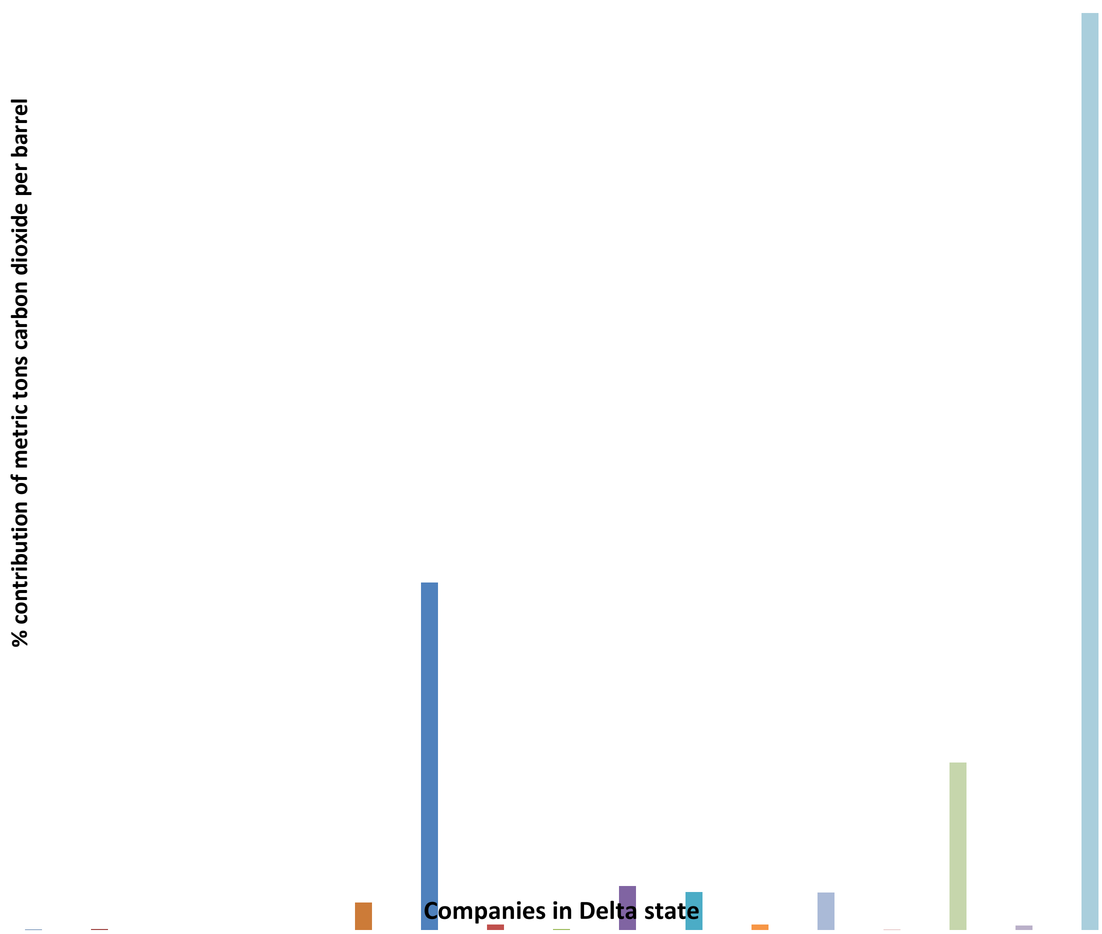


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Figure 4.4: Percentage contribution of CO_2/barrel emissions on oil spills in Delta State Nigeria (NOSDRA website).

4. Potential greenhouse gas emission contributions per companies in Bayelsa state

The significant contributing companies are SPDC and NAOC, with no significant contribution from Aiteo E & P (**See Figure 4.5**.).

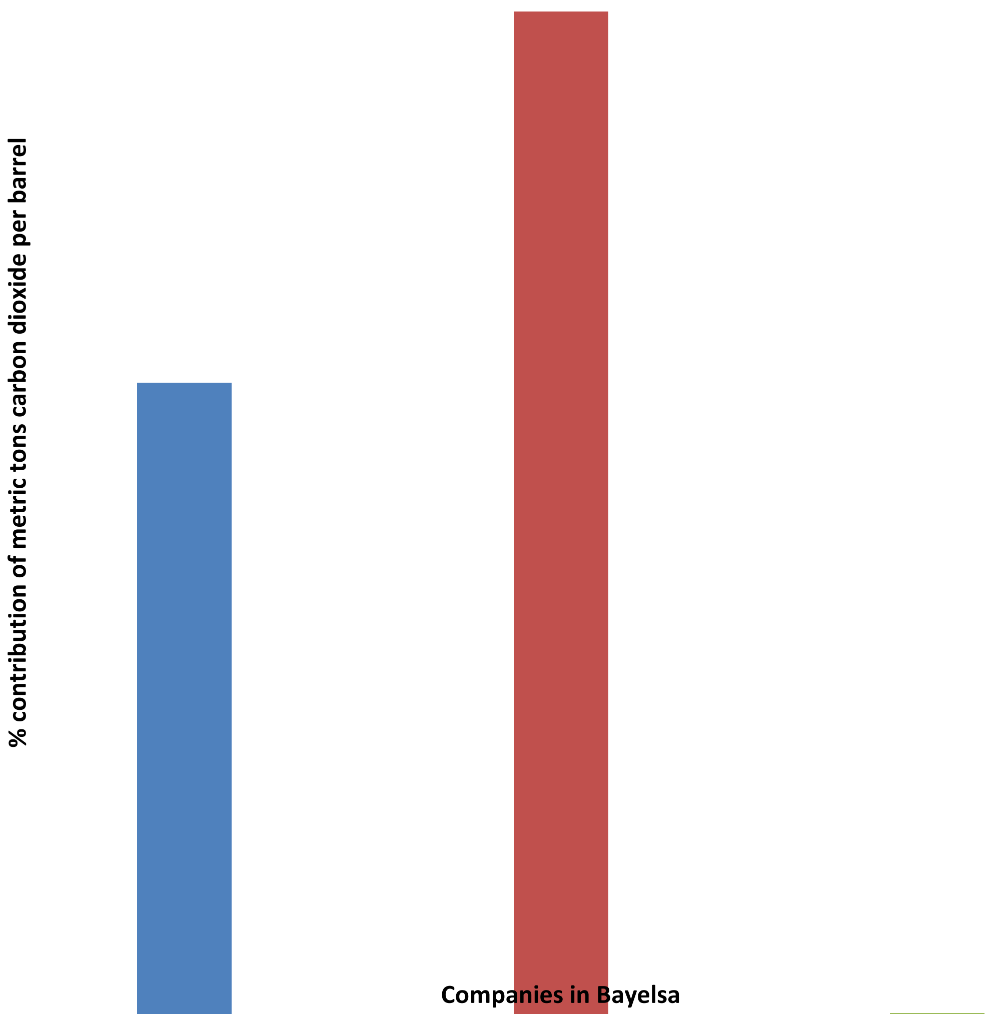

Figure 4.5: Percentage contribution of CO_2/barrel emissions on oil spills in Bayelsa State Nigeria (www.nosdra.gov.ng).

5. Potential greenhouse gas emission contributions per companies in Akwa Ibom state

In Akwa-Ibom state, SPDC is the sole potential contributor to greenhouse gas emissions with fewer contributions from PPMC (**See Figure 4.6.).**

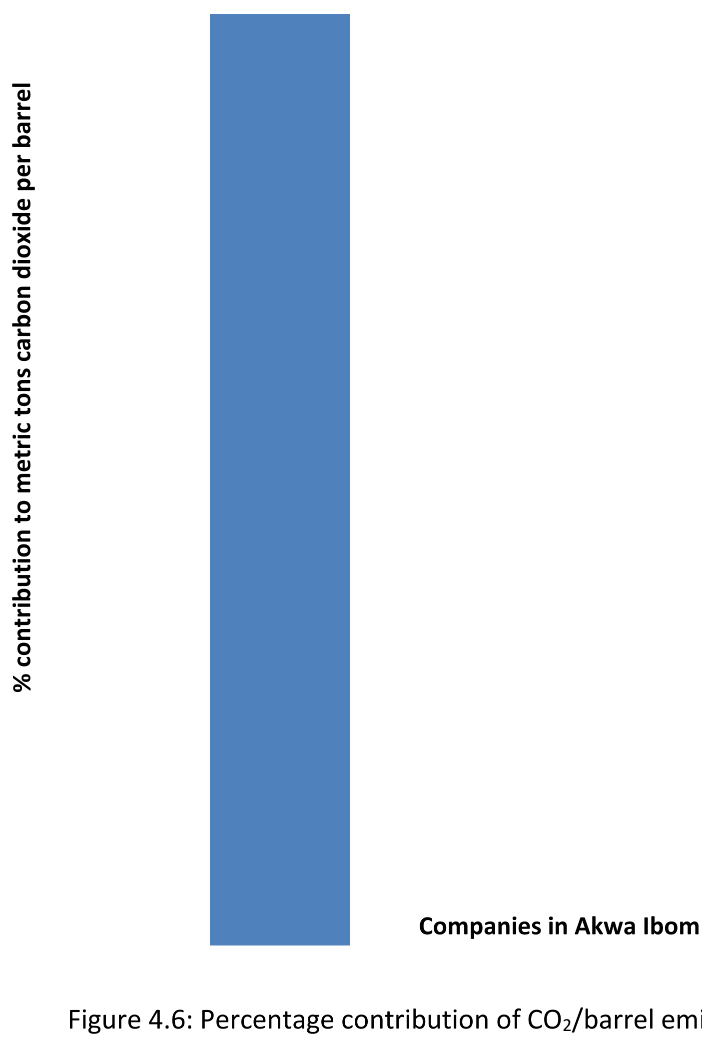

Figure 4.6: Percentage contribution of CO_2/barrel emissions on oil spills in Akwa Ibom State Nigeria (NOSDRA website).

6. Potential greenhouse gas emission contributions per companies in Imo State

In Imo state, the results are similar to Bayelsa state, where SPDC was the highest, and NAOC was in the second position with 66.5 % and 32.5 %, respectively (Figure 4.7).

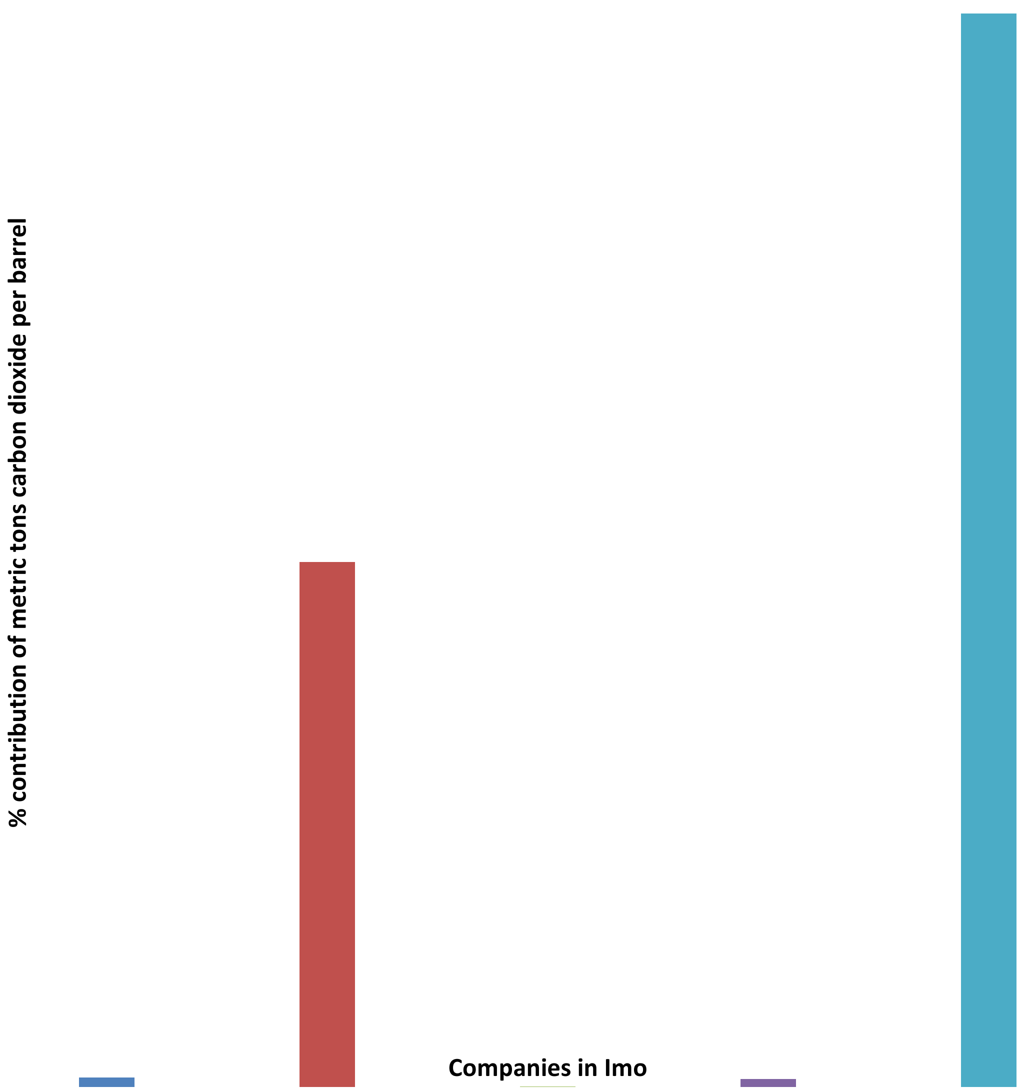

Figure 4.7: Percentage contribution of CO_2/barrel emissions on oil spills in Imo State Nigeria (NOSDRA website).

These calculations for the potential contribution of metric tons CO2/barrel revealed an excellent possible source of the challenge to climate change which was noticed across the Niger Delta region despite reducing the quantities generated in 2019 (Table 4.1).

Table. 4.1: Contribution of oil spill in Niger Delta to greenhouse gas released CO_2e/barrel

State	2018 (Oil Spill -barrel)	2018 (CO_2/barrel in metric tons)	2019 (Oil Spill -barrel)	2019 (CO_2/barrel in metric tons)
Ondo	2	0.86	- -	- -
Edo	158.2	68.03	11.70	5.03
Delta	5118.52	2200.96	693.81	298.34
Bayelsa	3932.45	1690.95	442.78	190.40
Rivers	11980.59	5151.65	907.62	390.28
Akwa Ibom	249.15	107.13	240	103.2
Imo	457.57	196.76	1730.06	743.93
Total	21,898.48	9416.34	4025.97	1731.17

The impact of greenhouse gases especially carbon dioxide will be felt for a long time and methane has 28 times of global warming potential than carbon dioxide in the Niger Delta region because it can stay in the environment for up to 100 years (Myhre et al., 2013).

CHAPTER FIVE

5.0. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study observed that:

1. The oil and gas industry has contributed yearly and massively to greenhouse gas emissions within the Niger Delta region, nationally, and globally.
2. Despite the Ministry of Petroleum in 2016 announced the country's endorsement of the "Zero Routine flaring by 2030 initiative", as an additional measure to combat climate change. We observed the poor implementation of Nigeria's NDCs and monitoring of the oil and gas companies for compliance in the effort to reduce greenhouse gas emissions and their contributions to climate change.
3. Implementing Nigeria's NDCs is limited, owing to the want for financial and technical resources for the execution of the goals of the Paris Agreement. If this agreement is not entirely undertaken, Nigeria may significantly incur adaptation costs from aggravated climate change soon.
4. Fines attached to gas flaring and venting by producers and permit holders are minimal. This has encouraged them to flare or vent gas continuously into the atmosphere. They understand that it is more economical to obtain the gas flaring permit and pay the associated fines than channel the flared gas into other energy sources such as the generation of electricity, cooking gas and other beneficial products to the host communities.
5. Fines attached to gas flaring or venting are also observed to be a source of revenue to the Federal Government. Political will may play some negative roles in the persistent greenhouse gas emissions by the oil and gas companies as it is perceived that the fines attached to oil and gas companies contribute to the national and economic development.
6. Weak enforcement tools have also contributed to the poor implementation of the NDCs Paris Agreement within the oil and gas sectors.

5.2 Recommendations

It is highly recommended that:

GOVERNMENT

1. Oil and gas companies should be enlightened on the impact of the flared gas, how it can be profitably converted to the generation of electricity through gas-to-power Plants using turbines at gas flare sites (microgrid). The electricity can then be connected to the national grid to help with the electricity challenge facing the country or supplied to local communities within the oil and gas companies, which will also help to reduce the number of users on the national grid.
2. The Nigerian government should sustainably develop and strengthen existing renewable energy infrastructure to reduce the prevailing impacts of the energy generated from oil and gas companies on climate change.
3. The Federal Government of Nigeria should also dedicate an agency with the sole responsibility of executing, monitoring and evaluating the implementation of the NDCs.
4. The implementation of the NDCs should be integrated into national development policy. It may be metamorphosed into poverty reduction, sustainable development and carbon trading to further help in combating climate change.
5. However, stringent laws should be enforced to restrict gas flaring and oil spillage in the Niger Delta, as these activities are always causing harm to the environment, bringing about inexplicable weather conditions, climate change, destruction of agricultural lands, deprivation of aquatic lives and rights, loss of biodiversity, and aggravated health problems among humans.
6. Climate finance is essential, and the government should fully exploit the Climate Innovative Finance and Clean Development Mechanisms (CDMs) to combat climate change.
7. There is a need for increased knowledge and awareness campaign for climate change risks and opportunities to help in the implementation of the NDCs.

OIL AND GAS COMPANIES

8. The flared gas should be channelled towards providing energy for households in Nigeria.
9. Oxidation catalysts can be used to reduce unburned emissions of hydrocarbons from flare stack. This will further help to aid complete combustion and prevent the escape of some greenhouse gases into the air environment.

10. The fines associated with gas flaring should be significantly increased, which will discourage oil and gas companies from flaring gas.
11. All oil and gas companies must submit a Field Development Plan along with viable and executable gas utilisation plans to the regulatory body. This submission must be followed with inspection and monitoring to ensure it is implemented as documented. The Field Development Plan will be consolidated with a steady reduction of existing flares through a combination of targeted policy interventions in the Gas Master-plan and the re-invigoration of the flare penalty through the 2016 Nigeria Gas Flare Commercialisation Programme, NGFCP.
12. Oil and gas should have greenhouse gas reporting program data that will be transmitted to appropriate authorities every year.

Lastly, this research will provide more light on the impact of oil and gas companies on climate change. Also, it can be carried out to examine the trend of oil spills for the past ten (10) years to ascertain if the rate is reducing or increasing and be able to develop a model to project the possible impact of greenhouse gases on the Niger Delta environment for the next ten years.

CIVIL SOCIETY ORGANISATIONS (CSO's)

1. Civil Society Organizations (CSOs) in Nigeria and those in the Niger Delta region in particular, need to act as watchdogs over the activities of oil and gas companies and the government's regulatory effort at ensuring compliance and commitment to cut down on greenhouse gas emissions thereby meeting the target set by Nigeria and the Paris Agreement.
2. CSOs should monitor the strict compliance with contract disclosure and revenue-transparency criteria to ensure that companies publish what they pay, and have the government disclose what they receive from defaulters in line with both international and local laws on gas flaring and spillages.
3. CSOs should promote better citizen engagement and participation in the decision-making process for an inclusive, participatory and transparent relationship among the communities, government and oil companies, respectively.
4. There is a need for CSO's to engage in big data gathering on gas flaring and oil spillages in the Niger Delta and other parts of the country.

COMMUNITY MEMBERS AND LEADERS

1. The communities and leaders need to cooperate with the CSOs and work closely to watch over the activities of oil and gas companies to ensure that their exploration activities do not only reduce GHG emissions but meet stipulated standards both locally and internationally.
2. Community leaders need to work with CSOs to better negotiate with the oil companies to ensure they fulfil their social responsibility for the development of their communities
3. They need to control youth unrest within their communities through partnership with the government, oil companies and other relevant stakeholders for youth development, including employment opportunities in oil and gas companies.
4. The community leaders need to build on the trust level existing between them and the people especially young people, government as well as with the oil and gas companies - this will guarantee peace and development of the region.

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