British Journal of Environmental Sciences 12(4),1-8, 2024
Print ISSN: 2055-0219(Print)
Online ISSN: 2055-0227(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development–UK

Evaluation of GHG Emissions on Climate of the Braced States in the Niger Delta

* **Paul Odiyirin Boyitie [1], Collins Oghenekome Ojoh[2] and Prince Ike Onyemenam[3]**
[1] Department of Meteorology and Climate Change, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria
[2,3] Department of Urban and Regional Planning, Dennis Osadebay University, Asaba, Delta State, Nigeria
Email: paul.boyitie@nmu.edu.ng
*Corresponding author

doi: https://doi.org/10.37745/bjes.2013/vol12n418 Published May 26, 202

Citation: Boyitie P.O., Ojoh C.O., and Onyemenam P.I. (2024) Evaluation of GHG Emissions on Climate of the Braced States in the Niger Delta, *British Journal of Environmental Sciences*, 12(4),1-8

ABSTRACT: *This study evaluates greenhouse gas emissions on the climate in the BRACED States of the Niger Delta. The emission of greenhouse gases leads to deforestation, reduced vegetation, and a decline in biodiversity. To achieve the study, an ex post facto research design was used. The study utilised field measurements and historical data to assess these factors. Data were collected and monitored from twelve distinct locations between September 2022 and February 2023. The findings indicate that Akwa Ibom had the lowest concentrations of greenhouse gas and climate variables. The concentrations of greenhouse gases and climate variables were found to be lowest in Akwa Ibom and Rivers States. Similarly, Rivers, Cross Rivers, and Edo States exhibited comparatively lower quantities of carbon dioxide emissions and low rainfall. The study's findings observed a strong correlation between climate (temperature and rainfall) and greenhouse gas emissions in the BRACED states. Statistical analysis at the $P<0.05$ level of significance indicates that greenhouse gas emissions account for around 32.5% of the observed variations. This analysis offers a method for determining the climate impact of GHG emissions. It is recommended that law on gas flaring activities should be brought to actions.*
KEYWORDS: GHG, emissions, rainfall, temperature, environmental externality

INTRODUCTION

Urban activities in the Niger Delta region have a substantial impact on the increase in temperature due to the release of greenhouse gas emissions (Echendu et al., 2022; Boyite et al., 2024). Wohllebe (2019) posits that under the current deforestation rate, the eradication of rainforests entirely could be achieved within four decades. This observation does not offer a substantial foundation for optimism regarding the potential of organic methods to mitigate global warming. The weather patterns experienced by the BRACED States are greatly influenced by human activities. Human activities have had a detrimental impact on the biodiversity of the area, resulting in a reduction in vegetation. Urban heat island effect has caused environmental issues in the BRACED states due to changing climatic patterns.

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This study is of significant relevance to a broad spectrum of stakeholders, including but not limited to government, geographers, climatologists, meteorologists, and environmentalists. This study is important because it offers valuable insights into addressing the challenges of climate change and greenhouse gas emissions (Malik & Ford, 2024). The study's findings have played a noteworthy involvement in the adverse impacts of greenhouse gas emissions (GHGEs) and climate change. The study evaluates greenhouse gas emissions on the climate of the BRACED States in the Niger Delta.

Conceptual Issues

Environmental externalities are the negative or positive consequences that are not accounted for or paid for by those who cause them or benefit from them in a regular market setting. The adverse consequences of oil and gas exploration and exploitation can be ascribed to flaws in governance. Government failure occurs when erroneous policies are implemented due to ignorance and incomplete information (Iyoha, 2002). Both instances of market failure and government failure have caused and continue to cause an excessive utilisation of environmental resources, resulting in environmental degradation.

Similarly, the unregulated and reckless behaviour of the oil companies in Nigeria when they burn off petrol results in extensive areas of the Niger Delta, especially the communities that rely on oil, being left barren and impoverished. This harms the overall welfare of the residents in the vicinity. Iyoha (2002) elucidated that clear instances of unidirectional externalities can be observed in the Niger Delta, such as oil spills (where the activities of an oil company impose costs on the residents of a community without providing any form of compensation) and gas flaring that deteriorates the soil nutrients, vegetation, air, and water.

The people of the Niger Delta region bear the direct consequences and financial burden of oil exploration and exploitation. This is accomplished through the process of causing widespread destruction and deterioration of soil, vegetation, and organisms, as well as exacerbating poverty. Oil industry activities often incur costs and inflict harm on host communities, without adequately compensating them for the true value of their resources. For instance, oil companies do not fully bear the costs associated with pollution of air, water, and land. Therefore, environmental externality aims to identify and measure the negative effects linked to gas flaring. The drawbacks encompass soil degradation, leading to diminished soil fertility and agricultural productivity, as well as air and water pollution, health issues, vegetation harm, and an overall menace to the ecosystem.

In addition to the European Commission, various scholars, including Sandmo (2011), Maloney and McCormick (2017), Yang (2020), and Harris and Roach (2021) have incorporated the concept of environmental externality into their research. The theory of environmental externalities is critical for evaluating the impact of greenhouse gas (GHG) emissions on climate in the Niger Delta. These emissions frequently produce negative externalities such as air and water pollution, deforestation, and climate change. Understanding these externalities is critical for policymakers and researchers developing effective GHG emission-reduction strategies, such as carbon pricing mechanisms, regulation of emissions from oil and gas operations, promotion of renewable energy sources, and support for sustainable development practices in the region.

Materials and Methods

BRACED States is located in Nigeria's coastal plain, encompassing 8600 square kilometers of swamplands and 2,370 square kilometers of rivers, creeks, and estuaries (Boyitie et al., 2024). The region is characterized by wetlands, mangrove forests, swamps, coastal ridges, and woodlands (Boyitie et al., 2024). The Niger Delta region, characterized by its semi-hot and humid equatorial climate, is home to the most extensive mangroves in Africa and the world's third-largest delta. The region's geography, including its geological formations and the presence of numerous rivers, contributes to the rise in precipitation due to elevated levels of evapotranspiration. Understanding the potential impacts of greenhouse gas emissions on mangrove ecosystems is crucial for addressing these issues. The BRACED States of the Niger Delta region, spanning nine states, has a population of 31.2 million, with projections of reaching 51.2 million by 2022. The region's uneven distribution is attributed to fragmented topography and global economic expansion, leading to increased greenhouse gas emissions. The region's combination of renewable and non-renewable resources contributes to environmental degradation.

This study analyses climatic variables and greenhouse gases in the BRACED states of the Niger Delta, Nigeria, utilising an ex post facto research design. Climate data, such as temperature, rainfall, and greenhouse gas levels, were generated using historical data and field measurements. Data were collected and monitored at twelve locations, including gas facilities and refineries, between September 2022 and February 2023. The greenhouse gases were chosen based on their widespread occurrence and ability to effectively trap heat, while climate data were obtained from the Nigerian meteorological agency. The months were selected to capture fluctuations during the peak of the rainy season and look into potential patterns or changes in pH levels over time (Payus et al., 2020). GHG measurements were obtained using a Sage thermal mass flow metre during an open-air sampling approach.

Gas measurements were taken in the early morning at 7am. and late evening at 7pm. This period was chosen due to the inherent volatility of the gases involved. Carbon dioxide, nitrous oxide, and sulphur dioxide were measured using a Sage thermal mass flow meter. This instrument automatically analysed ambient air based on its physical properties, sending a continuous output signal to an analyzer. The analyzer provided readings for carbon dioxide, nitrous oxide, and sulphur dioxide, which were displayed on the Sage meter's screen. The data was analysed with multiple regression. The distributions underwent basic descriptive analysis, and the variables were cross-tabulated. Multiple regression analysis was used to analyse the effect of greenhouse gas emissions (GHGEs) on the climate of the BRACED states. The data were double-validated before being analysed with SPSS version 21.

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RESULTS AND DISCUSSION

Table 1: GHG emission and Climate Pararmenter of the Niger Delta

States	SO_2 (µg/m³)	CO_2 (µg/m³)	NO_2 (µg/m³)	Temperature (^{0}C)	Rainfall (mm)
Akwa Ibom	12.0	23.2	21.0	28.3	1595
Bayelsa	24.5	26.8	26.0	28.4	2035
Cross Rivers	17.5	25.4	23.2	29.1	2022
Delta	23.3	26.3	24.6	28.8	2008
Rivers	25.5	25.4	28.2	28.4	2170
Edo	17.6	25.0	18.5	32.8	1584

Table 1 shows the observed fluctuations in greenhouse gas (GHG) levels and climate parameters, particularly rainfall and temperature, across the BRACED states. In contrast to other states, Akwa Ibom has the lowest levels of greenhouse gas emissions, as well as the lowest readings for temperature (28.3^{0}C), rainfall (1595mm), SO_2 (12.0 µg/m³), CO_2 (23.2 µg/m³), and NO_2 (21.0 µg/m³). Rivers State has the highest levels of greenhouse gas emissions among all states, as well as notable climatic indicators such as SO_2 (25.5 µg/m³), CO_2 (25.4 µg/m³), NO_2 (28.2 µg/m³), temperature (28.4^{0}C), and rainfall (2170mm). Increased SO_2 gas concentrations in the BRACED states are associated with increased rainfall patterns. Despite the observed increase in SO_2 gas levels and precipitation, there were a slight decrease in temperature across the Rivers and Bayelsa regions, as shown in Figure 1.

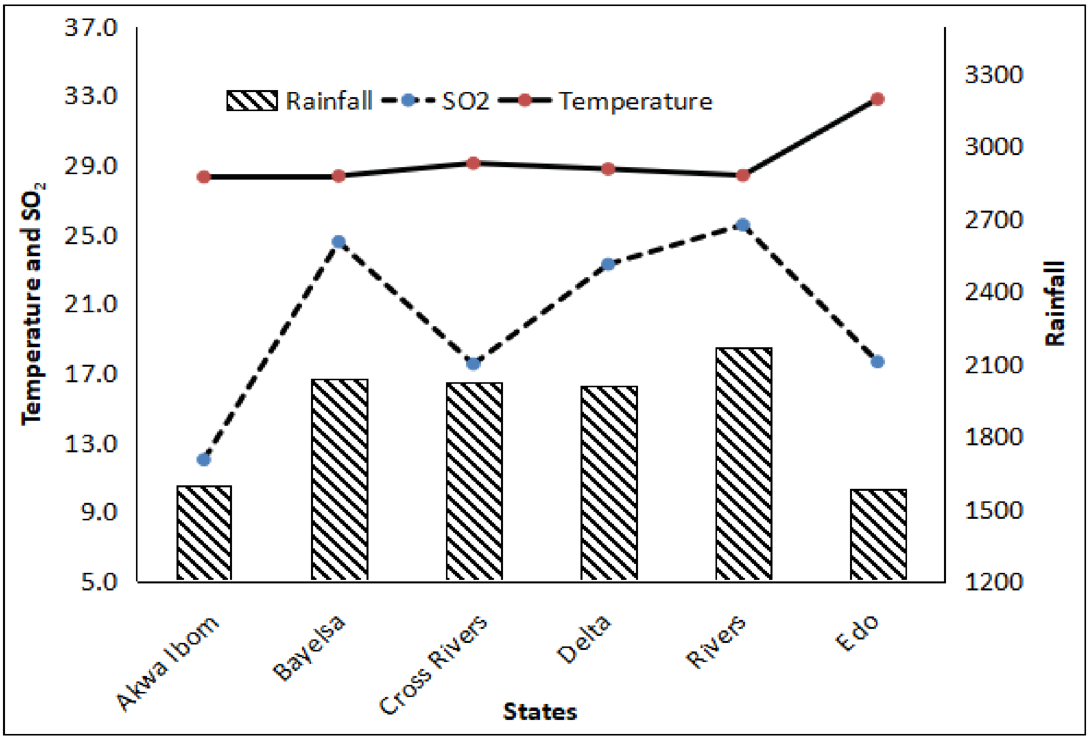

Fig 1: Temperature, Rainfall data and SO_2 Emission in the BRACED states

Carbon dioxide (CO_2) gas emissions in the BRACED states vary, with concentration levels decreasing in Edo, Cross Rivers, and Rivers States, respectively. Similarly, temperatures in Rivers

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State decreased. Figure 2 shows that rainfall has decreased in Edo and Akwa Ibom states. CO_2 emissions, temperature, and rainfall have all decreased in Akwa Ibom state. likewise, Edo state has the highest temperature, which is accompanied by a decrease in rainfall and CO_2 gas emissions. Despite variations in CO_2 emissions, Edo State experiences more warming.

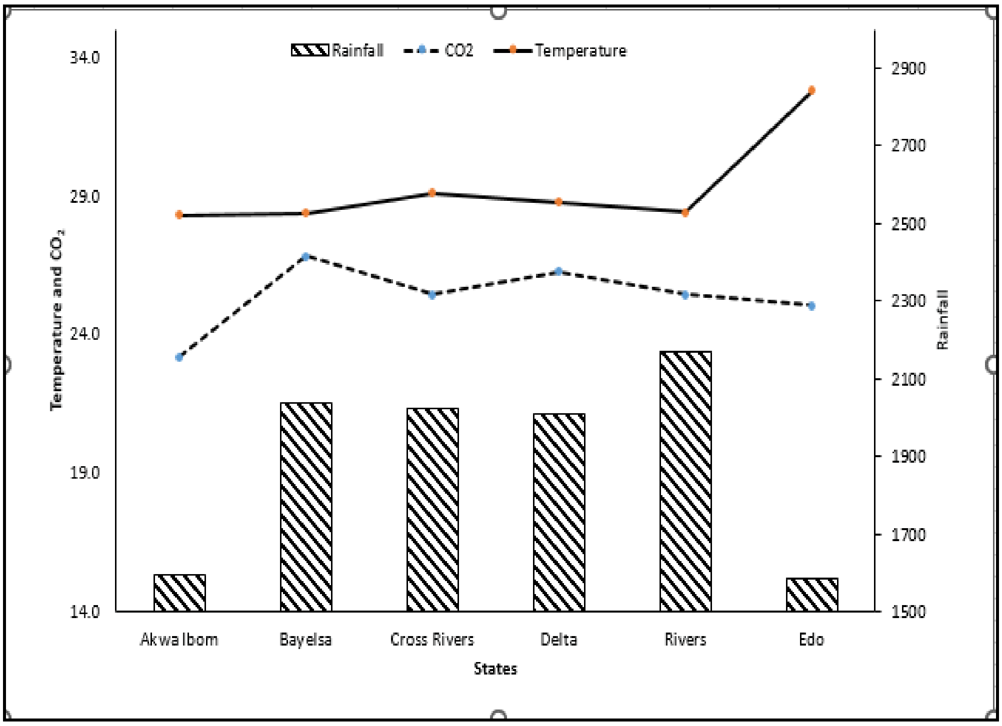

Fig 2: Temperature, Rainfall data and CO_2 Emission in the BRACED states

The amount of nitrogen dioxide (NO_2) gas released in the BRACED state varies over time. NO_2 concentrations declined in Akwa Ibom, Cross Rivers and Edo states. Similarly, temperatures in Rivers State, have decreased. Furthermore, rainfall decreased in Edo and Akwa Ibom states (see Figure 3). In Akwa Ibom state, nitrogen dioxide (NO_2) emissions, temperature, and rainfall amounts have all declined. In addition, Edo state has the highest recorded temperature, which coincides with a decrease in rainfall and NO_2 gas emissions. Despite the observed reduction in nitrogen dioxide (NO_2) emissions in Edo State, there has been an increase in temperature and a decrease in rainfall amounts.

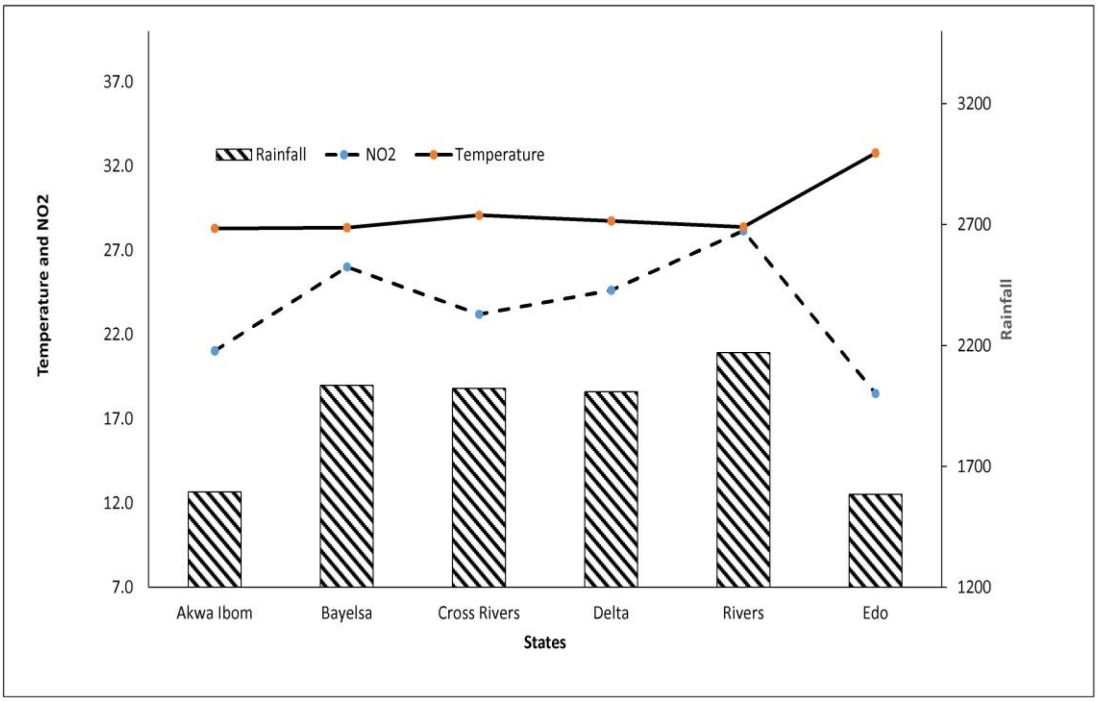

Fig 3: Climate and NO_2 Emission in BRACED states of the Niger Delta

Table 2: GHG emission and Climate

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.609[a]	.371	.325	8730.457	.371	7.975	2	27	.002
a. Predictors: (Constant), Rainfall, Temperature									

Table 2 shows the model summary outputs of the hypothesis, which states "Climate (temperature and rainfall) in the BRACED states is not significantly affected by GHGEs. The equation below defines the regression model as follows: Y represents greenhouse gas emissions, and X_1 and X_2 are the two independent variables. The specific equation is $Y = 346679.69 - 7033.061X_1 - 0.692X_2$.

In the Niger Delta region, there is a statistically significant positive correlation ($R = 0.609$) between greenhouse gas emissions and climate. Similarly, a r2 value of 0.325 indicates that greenhouse gas production accounts for approximately 32.5% of variations in rainfall and temperature in the Niger Delta. The result is statistically significant, which means that the null hypothesis is rejected. This conclusion is based on a computed F value of 7.99, which exceeds the critical table value of 3.35 at $P<0.05$. This implies that changes in precipitation and temperature patterns are primarily caused by the presence of greenhouse gases. The beta coefficient table indicates a statistically significant link between greenhouse gas emissions and temperature changes ($P<0.05$) (see Table 3). Furthermore, as greenhouse gas emissions increase, temperatures in the Niger Delta region rise proportionally.

Table 3: Coefficient Table

Coefficients[a]									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	346679.69	48641.48		7.13	.000			
	Temperature	-7033.06	1784.57	-.61	-3.94	.001	-.61	-.60	-.60
	Rainfall	.69	3.19	.03	.22	.829	-.10	.04	.03
a. Dependent Variable: Greenhouse_Gases GHG									

The Study found that Akwa Ibom has the lowest greenhouse gas emissions, temperature, rainfall, SO_2 (0.1µg/m³), CO_2 (23.2µg/m³), and NO_2 (21.0µg/m³) among other BRACED states. Rivers State has the highest emissions and significant climate variables. Despite rising SO_2 levels and rainfall, Rivers and Bayelsa had a slight drop in temperature. CO_2 emissions vary, with Edo, Cross Rivers, and Rivers States experiencing decreases. Despite rising temperatures and reduced rainfall, nitrogen dioxide (NO_2) emissions in Edo State have decreased. The model is significant at $P<0.05$, indicating that greenhouse gases cause rain and temperature changes and that increasing emissions contribute to proportional temperature increases.

CONCLUSION

The release of greenhouse gases has a significant impact on regional climatic patterns, resulting in more heat waves and shifting rainfall patterns. The study emphasises the importance of adaptation and mitigation strategies to reduce the region's exposure to climate change. Effective mitigation necessitates concerted efforts to address issues such as deforestation, industrial operations, and fossil fuel use. Recommendations include developing and implementing strategies to reduce greenhouse gas emissions across various sectors, transitioning to cleaner energy sources. This would entail mitigating rising temperatures, changing precipitation patterns, and devising climate adaptation strategies. The study also establishes a link between climate parameters and greenhouse gas (GHG) emissions, thereby providing a framework for assessing the impact of GHG emissions on climate. Further research should explore various mitigation measures been shown to be effective in reducing GHG emissions, such as carbon capture, utilisation, and storage (CCUS).

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