

# The impacts of gas flaring and climate risks: An appraisal of Nigerian petroleum industry

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**Abstract**— Gas flaring poses significant risks to health, safety and the environment. Although significant attentions have been given to the subject over the years, however, the increasing challenges especially in view of climate change risks prompts a serious urgency to examine the way forward. The nature of impacts from climate risk depends on the intensities of extremity in view of resources management and in consideration of the exposure and vulnerability of human populations and properties. This study through a review of existing literature in the field reveals paradoxical evidence in the management of climate risk especially as attempts to eliminate such risk and its impact ultimately create another risk (risk homeostasis). In this context, the research found that the level of vulnerability of human populations to the health implications of gas flaring depends significantly on the proximity of the human receptor to the flaring stations. Following a critical appraisal of the activities of oil and gas companies in Nigeria, the result suggests that climate risks might have caused much damage than was previously imagined. Therefore, we argue that promoting effective techniques on how to practically live with climate risks such as adaptive environmental management will help policymakers and practitioners' particularly in Nigeria and indeed in other parts of the world subjected to the impacts of gas flaring, to sustainably tackle climate risks.

**Keywords:** *Gas flaring, Climate risk, Nigerian oil and gas companies, Paradoxical evidence, Risk homeostasis, Vulnerability and exposure, climate risk damage, Adaptive environmental management.*

## 1 INTRODUCTION

Climate risk relate specifically to the risk of climate change. The nature of impacts from climate risk depends on the intensities of extremity in view of resources management and in consideration of the exposure and vulnerability of the affected human populations and properties. Not only are the adverse effects of climate risks and the vulnerabilities of stakeholders well documented, but also they are global concerns (Nkwunonwo & Mafimisebi, 2013). However, several stakeholders within the Nigerian petroleum industry (for example, the Nigerian government, oil and gas companies, host communities, etc.) are affected differently by the recurring impacts of climate risks (Aigbedion & Iyayi, 2007).

Similarly, gas flaring in Nigeria has been found to impact adversely on the environment, health and safety of local people living near the flaring stations in the Niger Delta region (Nwaugo et al., 2006; Elvidge et al., 2009; Steiner, 2010). While empirical studies have not clearly demonstrated that gas flaring accounts considerably for climate change because of the difficulty in quantifying the exact levels of emissions, it remains one of the major environmental concerns (Bassey, 2008;

Ovuakporaye, 2012). In the Niger Delta region of Nigeria, this is a critical issue and perhaps one that has not been well addressed. Surprisingly, there are little proactive measures to end gas flaring, however, reactive measures are arguably in place to favour business cases in Nigeria. Until recently, a number of critical questions which have led to considerable interest towards evaluating the impacts of climate risks on stakeholders have been considered such as: How does gas flaring and climate risk affect different stakeholders? What strategies are needed to effectively manage the environmental impacts arising from gas flaring and climate risks? How do gas flaring and climate risks possibly pose economic, environmental and human rights challenges? Are there any current universal model to effectively manage the environmental impact of gas flaring and climate risks? These questions also offer useful insights into the best approaches to be adopted towards managing the environmental impacts of climate risks and gas flaring (Aghalino, 2009).

The concern for ending gas flaring in Nigeria is complex and includes poverty and sustainable development, health and safety, human rights, economic and environmental implications (Bassey, 2008). For example, the Nigerian petroleum industry is estimated to have about 120 trillion cubic feet (representing an equivalent of approximately 20 billion barrels oil) of gas reserve thus ranking as the 10<sup>th</sup> largest gas reserve worldwide (Omisi, 2001: 2). Moreover, flaring of associated gas (AG) is anticipated to cost Nigeria US \$2.5 billion annually (Environmental Rights Action [ERA], 2005; 2012). The trend has steadily increase and natural gas reserves of Nigeria are now estimated at 174 trillion cubic feet (cf) suggesting that the country's oil reserves would last for additional 37 years while

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gas reserves should marginally last for 110 years (Ayoola, 2011). However, the exactness and reliability of these deductions and their possible implications are uncertain.

Critically, there are conflicting figures on the quantity of crude oil and AG exploited in Nigeria. In 2000, for example, some experts revealed that over 3.5 billion standard cubic feet (scf) of AG was produced of which more than 70 per cent was flared (Friends of the Earth, 2004). Contrarily, in a paper presented by Omiyi (2001) it was revealed that about 1000 scf of AG is produced along with each barrel of oil exploited in Nigeria with 17% of it is re-injected, 33% used and the remaining 50% flared. In perspective, research findings revealed that with every 2.2 million barrels of oil produce daily; approximately 2.2 billion scf of AG were correspondingly produced in Nigeria. This is equivalent to almost 25% of the gas consumption in the UK (Friends of the Earth, 2004).

From these facts and figures, it is therefore clear why the objections of some environmentalists and campaigners alike who condemned gas flaring activities, for which attention has been called to their environmental impacts and economic loss in Nigeria. Quite significantly, as Nigeria oil production increased, the country has steadily become the world's biggest gas flarer with about 3 billion scf of AG being flared daily. Though there are conflicting figures and opinions as to the exact volume of AG flare in Nigeria and how potentially the practice of flaring gas could significantly escalate climate risks. Nevertheless, empirical studies have established that gas flaring pose serious threat to health and safety, environment and institutional stakeholders (Bassey, 2008).

We therefore posit that there is need for critical concerns especially utilising proactive measures to actively end flaring of AG in Nigeria and effective reactive measures to disfavour business case for not ending gas flaring in Nigeria. Thus, the main purpose of this article is to critically evaluate and explore the impact of gas flaring and climate risk in Nigeria drawing on the case study of Nigerian petroleum industry. Within the realm of environmental management, gas flaring and climate risk continue to create critical challenges for their management. In this context, we explore and evaluate how gas flaring and climate risk impact on the environment, stakeholders and how collective institutional resilience could be built to enhance better and effective management of gas flaring and climate risk. The prime focus is on adaptive environmental management: identifying, evaluating, and managing climate risk in Nigeria and to uncover practical environmental risk management paradigms in addressing the environmental problems (risks) created as a result of gas flaring and climate change in Nigeria.

Previous studies on climate change rely sporadically on preventive and adaptive measures (for example, Waugh, 2000; Willows & Connell, 2003; Walker et al., 2004; Nigel & Rice, 2010), risk regulation (for example, Heyvaert, 2011), environmental legislation (Eweje, 2006), environmental reporting and accounting (Prato, 2007; Ayoola, 2011), and massive discontinuous change (Winn et al., 2011) as methods for managing climate risk. It is useful to note that because these methods as revealed are limited in scope and applications, there is need

for collective workable model (at least) to help coordinate and manage climate risks. Notably, these studies have demonstrated how climate risk affected businesses, nations, communities and individuals through the various concepts highlighted.

However, while the effects of climate risk and gas flaring continues to generate increasingly concerns and attention (see, for example, Kindzierski, 2000; Omiyi, 2001; Ikporukpo, 2004; Aigbedion & Iyayi, 2007; Bassey, 2008), we critically appraise existing frameworks and then reveal best practices in managing climate risk. The study revealed where resources, attention, priorities and strategies should be directed towards improved techniques to eliminate gas flaring and minimise (if not eliminate) the detrimental environmental impact of climate risk. The main problem here is that developing a universal model for managing climate risk is a mirage because of the complexity involved. Yet, this research reveals the need for such model and addresses the important debate in which climate risks cannot be manage systematically but conceptually. In other words, attempt to methodically manage climate risk is an illusion. One possible explanation for this paradigm is because there can never be complete elimination of climate risk and attempt to systematically model climate risk would potentially create another risk (risk homeostasis).

Likewise, the regime change in approach for global efforts to manage climate risk continues to differ among countries. In essence, climate risk is a scourge which thrives unnoticeably to harm the environment, affect health and safety, and practically affect businesses and nations negatively thus describe simply as a soft weapon of mass destruction. So what are the possible implications and how could organisations who continue to flare gas in Nigeria manage such climate risk? Lastly, how possibly can the impact of gas flaring and climate risks be managed? Is there any best practice regarding the management of climate risk across the globe?

The fundamental concerns remain the way every stakeholder best prepares for and adapt to environmental impacts of gas flaring and climate risk. Meanwhile, before policymakers and stakeholders can effectively manage such environmental impacts, appreciating the phenomena of climate risk and gas flaring impact remains essential. Therefore, in the first instance, the study reviews the Nigerian petroleum industry to provide a conceptual case study and model the environmental account of the industry. The subsequent sections critically examine the concept of adaptive environmental management; reveal the impact of climate risk and gas flaring on the environment, human health and safety, as well as economic implication on the relevant stakeholders. The final section draws extensively on the discussion surrounding adaptive environmental management. It draws attention to the paradigm of living with the environmental impacts of climate risk and the consequences of implementing such strategies. More specifically, the study proposes and sheds light on the concept of adaptive environmental management and argues for deliberate attempts to meaningfully reduce climate risk while living with the consequences. Conversely, the study recognises the need to eliminate climate risk (if possible) and halt activities that directly escalate the risk. However, much of the ar-

guments are in favour of stakeholders' resilience and adaptive environmental management framework. In conclusion, the study reveals paradoxical evidence in the management of climate risks especially as attempts to eliminate the risks and their impacts ultimately result to risk homeostasis.

## 2 NIGERIAN PETROLEUM INDUSTRY: A CASE STUDY

The Nigerian petroleum industry advances since the last 56 years when oil was discovered in commercial and economically viable quantities at Oloibiri town (Bayelsa State, Nigeria) in 1958. Though, in Nigeria, oil was first discovered in 1908 at Araromi (Ilaje Local Government Area, Ondo State, Nigeria) by the Nigeria Bitumen Corporation (a Nigerian-German company) but oil exploration and exploitation activities ended abruptly due to economic reasons. However, as the Nigerian petroleum industry advances, Nigeria is now the biggest oil producer in Africa and 11<sup>th</sup> largest in the world and since 1971 has been a member of the Organisation of Petroleum Exporting Countries (OPEC). In context, the Nigerian oil and gas exports accounted for about 98% of export earnings, 95% of foreign exchange earnings and almost 83% of Nigerian government revenue and 65% of government budgetary revenues, but surprisingly contribute less than 2% of the GDP (Bassey, 2008; Aigbedion & Iyayi, 2007).

This suggests that the industry is not adding much real value to the Nigerian economy as previously imagined instead it causes detrimental impacts on the environment, health and safety as well as non-oil businesses such as farming, fishery and hunting. Although there could be obvious counter arguments in favour of the perceived benefits of the sector, nevertheless, complete appraisal of the industry would help relevant stakeholders understand how the industries affect them: positively or negatively (Bassey, 2008; Aghalino, 2009; Elvidge et al., 2009; Steiner, 2010). As a follow up to such appraisal, this research represents an independent critical assessment of the Nigerian oil and gas industry with respect to the impact of gas flaring and climate risk on stakeholders.

The industry is a major supplier to the United States supplying (for instance) approximately 1.1 million barrels per day (bbl/d) in 2004 when compared with 589,000 bbl/d in 2002; accounting for oil export revenue of estimated \$27 billion in 2004 (ERA, 2005). There were 606 oil and gas fields in the Niger Delta, 355 onshore and 251 offshore, of which 193 were producing in 2002 (ERA, 2005). Much uncertainty surrounds the reliability of this statistics especially as there are conflicting data. In contrast, according to the Ministry of Petroleum Resources, there are a total of 159 oil fields and 1481 wells in functional operation (Environmental Resource Managers Ltd, 1997). There are over 200 gas flaring stations in Nigeria most of which have been flaring AG continuously for over twenty years. However, the oil fields are dispersed across the Niger Delta region where extensive flowlines and pipelines network are developed to enhance and transport the crude oil. Key stakeholders have failed to provide exact number of oil wells and fields in the entire industry. In this regard, we argued that

oil theft would continue to thrive as long as conscious coordinated approaches to provide the exact data of the number of oil fields and wells, barrels of oil produced daily, cost and selling price, and transparency within the petroleum industry are lacking. This calls for empirical research and attention of policymakers and relevant stakeholders to critically examine these issues.

It is critical to state that all petroleum exploration and production within the Nigerian petroleum industry is operated as joint venture business between the Nigerian federal government (through the Nigerian National Petroleum Corporation (NNPC)) and multinational oil and gas companies (for example, Shell-BP, ExxonMobil, ChevronTexaco, Agip, TotalFinaElf). Research has shown that the joint-venture accounted for almost 95 per cent of all crude oil output and the rest 5 per cent are captured by the local independent oil companies. Nigeria has six petroleum exportation terminals (Qua Iboe Terminal in Akwa Ibom State, Escravos Terminal and Forcados Terminal in Delta State, Brass Terminal in Bayelsa State, Bonny Terminal and Pennington Terminal in Rivers State) where crude oil exportation activities are carried out.

The key multinational oil corporations (Shell, ExxonMobile, ChevronTexaco, Agip and TotalFinaElf) in Nigeria operate jointly with the NNPC which holds between 55% and 60% in each of the joint ventures. Shell-BP, ExxonMobil, ChevronTexaco, Agip and TotalFinaElf carried out about 95% of Nigerian oil and gas production (ERA, 2005). These multinational companies have come under heavy attacks for polluting the environment and taking away the source of livelihood of the people who primary dependent upon agriculture in the Niger Delta region of Nigeria. This has been the proximate cause of the 'walking' crises within the Nigerian Niger Delta affecting the local communities, multinational oil companies and Nigerian government. Meanwhile, significant to the industry, the Nigeria Constitution, Petroleum Decree of 1969, Land Use Act 1979 and the recent Petroleum Industry Bill legally vested all minerals, oil and gas resources on the federal government. This has clear implications on the concept and agitation surrounding resource control and royalties within the industry. These issues are not within the aims and objectives of this study but could be subject to proper research in the future.

## 3 ADAPTIVE ENVIRONMENTAL MANAGEMENT: CONCEPTUAL FRAMEWORK

The management of climate risk and gas flaring creates enormous challenges for stakeholders. In this vein, there have been deliberate attempts to manage climate risks and gas flaring, however, different conceptual models has evolved. However, of particular interest, within the field of environmental management are some arrays of concepts such as sensitivity, vulnerability, resilience, risk mitigation, disaster risk reduction, coping capacity, adaptation, adaptive capacity, discontinuous environmental change, and hyper-turbulent environment among others have emerged in the literature (Adger et al., 2002; Burton et al., 2002; Luers et al., 2003; Brooks, 2003; IPCC, 2007; Winn et al., 2011). There are contradictions in the litera-



ture regarding the actual meanings of these concepts and the choice of meaning perhaps depending on the context and users. In this research, the focus is on the concept of adaptability which refers to the ability or capacity of a system to modify or change its circumstances or behaviour so as to cope better within existing and anticipated external shocks (Brooks, 2003). Empirical research suggest that adaptive capacity represents potential rather than actual adaptation (the process through which adjustments take place in the behaviour of a social or biophysical system to enhance its ability to cope with shocks and crises) (Adger et al., 2002; Luers et al., 2003; IPCC, 2007, Winn et al., 2011). The uncertainty surrounding the concept of adaptive capacity and adaptability is as much as that of climate risk. There is evidence to argue that adaptability or adaptive capacity cannot actually be measured because of the complexity of social, economic, and biophysical environmental agents involved. While these terms - adaptability, adaptive capacity, adaptation, and coping capacity are sometimes used interchangeably and controversially, the extent to which stakeholders can adapt to environmental disasters remains paramount and crucial for effective management of environmental problems.

Building on the concept of adaptive capacity from the literature, the term 'adaptive environmental management' is used to capture the identification, evaluation, and management of risk and applying the best practical environmental risk management options in addressing the environmental problems (risks) created. The scale, scope and systemic uncertainty connected with environmental disasters required considerable attention. However, given the complexity, ambiguity and uncertainty surrounding environmental problems, the issue becomes how can stakeholders measured the outcome of adaptive environmental management approach. Nevertheless, understanding how best to adapt to inevitable risks of climate and associated problems is imperative for effective decision-making. Quite importantly, there are three identifiable adaptation strategies recognised in literature which include proactive, reactive and inaction (postponing responses or do nothing). The choice of option has practical implication on the management of climate risk and gas flaring in Nigeria.

#### **4 GAS FLARING AND CLIMATE RISKS: TOWARDS ADAPTIVE ENVIRONMENTAL MANAGEMENT FRAMEWORK**

This research has been about critical evaluation of the impact of gas flaring and climate risks in Nigeria. In this study, climate risks has been defined as a scourge which unnoticeably thrives to harm the environment, affect health and safety, and practically affect businesses, local communities and nations negatively thus describe simply as a soft weapon of mass destruction. Arguments in favour of a conceptual model to manage the environmental impact of gas flaring and climate risks have been made. In this instance, a counter argument of systematic model of climate risk was likewise brought to lime-light. However, as clearly demonstrated previously, existing literatures (for example, Adegemi, 2000; Kindzierski, 2000;

Omiyi, 2001; Ikporukpo, 2004; Aigbedion & Iyayi, 2007; Bassey, 2008; Opukri & Ibaba, 2008; Madueme, 2010a, 2010b) on gas flaring and climate risks remained disjointed and underdeveloped in terms of best practice and framework to guide policymakers and relevant stakeholders in the environmental management of climate risk and gas flaring. What practical implication could this has on stakeholders and principal decision-makers on environmental risk? More specific goals have to be targeted using the concept of adaptive environmental management.

One possible theory is that climate risks continue to thrive and escalate partly because of the difficulty in harnessing opportunities in previous cases of crises and disasters using the lessons learned approach. Critically, despite the concern for health and safety, human right, poverty and sustainable development, environment and economic implications due climate risks and gas flaring, universally acceptable framework to manage climate risk did not exist. This is understandable as regime change for climate risks continue to deviate from country to country, continent to continent, and between developed and developing nations. The commitments to collectively tackle and manage climate risks are non-proportional among policymakers and stakeholders. At the international arena, the Intergovernmental Panel on Climate Change, United Nations Framework Convention on Climate Change, Kyoto Protocol, 2007 Bali Climate Declaration by Scientists, and World Bank Global Gas Flaring Reduction continue to inform debates and policy towards ways of addressing the threat.

Meanwhile, the levels of commitments are not clearly the same and potentially differ among stakeholders. For example, the European Union (EU) demonstrated well-established reputations towards risk regulation and legislation on climate change, and adopted regulatory measures aimed at reducing its own carbon footprint by at least 20% by 2020 (Heyvaert, 2011). In Nigeria, the legislative instruments such as Associated Gas Re-Injection Act 1979, Oil in Navigable Waters Act 1990, Nigerian Gas Master Plan 2008, Environmental Impacts Assessment Act 1992, National Environmental Standards and Regulation Enforcement Agency Act 2007, and Gas Flaring (Prohibition and Punishment) Act 2009 are some of the initiatives towards the environmental management of gas flaring and protection of the environment. Through critical appraisal of the Nigerian petroleum industry, it appears that such level of commitment as demonstrated by the EU is lacking in Nigeria and by extension the African Union (AU).

However, it is not surprising as the concern for the environment and sustainable environmental development tends to significantly differ between developed and developing countries. To put this into perspective, while most of the developed countries have shown real commitment through legislation and enforcement towards effective management of climate risk, developing countries such as Nigeria tend to pay lip-service. For example, on gas flaring for which empirical studies have shown how it contributes to climate change, Nigeria has consistently shifted the deadline for ending gas flaring such as 1979, 2004, 2007, 2009, 2010, and 2012. In contrast, Nigeria's commitment towards environmental management of

gas flaring and climate risk is recognised but prior approach towards climate risks in the country are ineffective and mostly reactive in nature. In this regard, the commitments that efforts are in place to manage climate risk is parallel to actual and proactive efforts to curb climate risk. It is therefore crucial for policymakers and relevant stakeholders to learn from previous similar experience and cases of climate risks disasters across the globe. This would help develop appropriate proactive strategies towards environmental management of climate risk. Essentially, the need for caution in processes of managing climate risk cannot be overstated.

It is argued that by drawing on the lessons learnt approach and the concept of adaptive environmental management, policymakers and key stakeholders would understand to a large extent where the resources, attention, priorities and strategies need to be directed towards improving techniques to eliminate gas flaring and minimise (if not eliminate) the detrimental environmental impact of climate risks. The lessons learned approach is an approach which draws on lessons from previous cases of similar environmental issues and applying impactful techniques to meaningfully manage current challenges/cases based on experience and history. Although the issue of complexity involvements in climate risks can hinder strategic options, it is strongly believed that the need for such model and question that climate risk cannot be managed systematically but conceptually is imperative for sustainable environmental management. In different context, attempt to methodically manage climate risk is a phantasm. One possible explanation for this paradigm is because there can never be complete elimination of climate risks and attempt to systematically model climate risks would potentially create another risk (risk homeostasis).

Equally, the regime change in approach for global efforts to manage climate risks continues to differ among countries. In the UK, the Climate Change Act (2008) requires government to implement policies to adapt to climate change and prepare environmental risk assessment of climate risk impacts to the UK to the year 2100. It is expected that the environmental risk assessment will be accompanied with an Adaptation Economic Assessment (AEA) which will assess options for dealing with the biggest risk based on their costs and benefits considerations. This is a proactive method for dealing with climate risks; however, we argued that there could be systemic risk of tick-box approach such that climate risks are not effectively managed in the long run. Nevertheless, there is no specific legislation governing the environmental management of climate risk in Nigeria. This suggests that the country has not yet completely learn from events around the world. It is recommended that there is need for specific legislation to govern climate risks in Nigeria.

As revealed by Winn, et al. (2011), climate risks generate both strategic challenges and opportunities for business organisations, shifting competitive and regulatory environments indirectly through global political efforts to constrain carbon emissions and directly through bio-physical impacts such as extreme weather event. Essentially, every stakeholders need to clearly understand the impacts of climate risks on them and

how to effectively manage such impacts. Building on the concept of climate change from the literature, we propose that adaptive environmental management which suggests the deliberate efforts towards living with climate risk through critical identification and evaluation of the severity, vulnerability, frequency and scale, to practically understand how to reduce the impacts while cautiously living with the consequences is crucial.

Critically, it is arguable that adaptive environmental management might serve as incentive to increase climate risk again especially as some practitioners and policymakers would be reluctant to proactively reduce activities that contribute significantly to climate risks. A review of empirical research on environmental management shows that climate risk and gas flare impacts have generated much attentions, nonetheless, quite little attention has been paid to the contrary (with few exceptions). Climate risks been unequivocally recognised as a major environmental threat but understood differently, hence, the need to target systemic risk (change) rather than elimination, reduction and stabilisation must facilitate debate. In conclusion, the successful and effective management of climate risks demand adaptive environmental management approach as advocated in this research.

#### 4.1 GAS FLARING

It is critical to note that Nigeria lost almost \$72 billion in revenues between 1970-2006 and approximately \$2.5 billion yearly (Bassey, 2008). Worse still as shown by a number of studies, is that out of the global 168 billion cubic meters of AG flared annually, about 13% (about 23 billion cubic meters) comes from Nigeria. In perspective, this was found to represent almost 25 per cent of the US gas consumption and 30% of the consumption of gas within the EU. In other words, the volume of AG flared in Nigeria is more than enough to meet the country's energy needs and further contribute to export. In another case, empirical research indicated that gases emitted into the atmosphere in processes of gas flaring contain carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), dioxin, xylene, styrene, naphthalene, benzene, hydrogen sulphide, toluene and other carcinogenic volatile organic compounds (Oruamabo, 2005; ERA, 2005; Bassey, 2008).

In terms of human health and safety, scientific researchers have linked breathing of particulate matter to a series of significant health related problems such as aggravated asthma, increase in respiratory symptoms like coughing and difficult breathing, chronic bronchitis, decreased lung functions, and premature death (for example, Ologunorisa, 2001; ERA, 2005). In addition, it has been established and accepted that exposure to benzene and its metabolites cause acute nonlymphocytic leukaemia and a diverse of other blood-related disorders in humans (US EPA, 1997). In clear simplification, gas flaring is partly responsible for pneumonia, cases of leukaemia, decreased lung functions, difficult breathing, and increase mortality and morbidity rate in Nigeria.

This study attributes the level of vulnerability with regards to the health implications of gas flaring to the proximity of the human receptor to the flaring stations. This suggests that peo-

ple living very close to the flaring stations are more vulnerable to the detrimental effects of gas flaring than others. By extension, and drawing from the previously discussed concept of adaptive environmental management, it is recommended that vulnerable people living close to flaring stations should relocate and possibly find alternative sources of livelihood. Clearly, it is needful that stakeholders should collectively manage the negative impacts of gas flaring. The Nigerian government and multinational oil companies would need to rethink on strategic approach towards ensuring crises and disasters free-environment. One-off theory is that reluctance in harnessing resources to end flaring and provide institutional supports to vulnerable local people in the Niger Delta region of Nigeria would further deepen frustrations, agitations and crises within the country. Perhaps, this might not be unerringly true; however, the consequence of disregarding such essential paradigm is obvious.

## 4.2 CLIMATE RISK: THE ROLE OF GAS FLARING

Research has revealed the greatest impacts of climate risks on low-lying coastal areas such as the Niger Delta region of Nigeria. The attendant consequences include freak weather events, incessant flooding, coastal erosion, sea level rise, proliferation of pests and spread of diseases, as well as destruction of agricultural productivity. Empirical studies have likewise demonstrated that gas flaring contribute significantly to climate risks (Oruamabo, 2005; Bassey, 2008; Heyvaert, 2011; Ayoola, 2011). Critically, what is the proportion of gas flaring that contributes to climate risks? Gas flaring releases greenhouse gases including carbon dioxide and methane into the atmosphere. Research indicated that methane is in fact more harmful than carbon dioxide (Steiner, 2010). However, carbon dioxide emissions in Nigeria have been found to be among the highest within the international communities (Iyayi, 2004). In another instance, research indicates that extremely high levels of carbon dioxide and methane gases released in processes of flaring AG meaningfully impact the climate above the local level and causing similar effect on the ozone layer (Trip Report, 1999; Bassey, 2008). Most crucially, there is significant causation between gas flaring, ozone layer depletion, climate risks and acid rain in the context of existing research. While this has not been empirically proven, there is need to slow down or proactively reduce operations that constitute climate risks.

Though, it has been revealed that because of infrastructural inefficiency most of the AG flare in Nigeria is released as methane ( $\text{CH}_4$ ) rather than carbon dioxide ( $\text{CO}_2$ ) (Eweje, 2006). Nevertheless, empirical studies (for example, ERA 2005) have found that  $\text{CH}_4$  has larger global warming potential than  $\text{CO}_2$  though it is shorter lived. In this case, studies have shown that 1kg of  $\text{CH}_4$  is 62 times more powerful than 1kg of  $\text{CO}_2$  when exposed over a period of time say 20 years.

Reflectively, what does this mean for the environmental management of climate risks? Several attempts have been made to evaluate the exact volume of gas flared in Nigeria. Unfortunately, such studies did not clearly demonstrate how gas flaring constitutes climate risks and how such risks can be

manage. For instance, Kindziarski (2000) concluded that the effects of gas flaring on human health include cancer and non-cancer, neurological, reproductive, and development effects. In another context, gas flaring constitutes climate risks and cause noise and air pollution, increase temperature rise, acid rain, roofs corrosion and respiratory diseases in Nigeria. This research has revealed that the level of vulnerability depends on the proximity of social systems to the flaring stations. However, research suggested that gas flaring causes disturbed sleep rhythm because of the bright light and heat from the flares; and result in low white and red blood cells counts in host communities with the possibilities of impaired resistance to infection (for instance, Oruamabo, 2005). A critical appraisal of the activities of oil and gas companies in Nigeria suggest that climate risks might have caused much damage than was previously imagine. We argue that promoting effective techniques on how to practically live with climate risks will help policymakers and practitioners to sustainably tackle climate risk. The potential implications are quite predictable on vulnerable people living close to flaring stations within the Niger Delta region, Nigeria. This could be a guide for adaptive environment management practice and inform relevant stakeholders on the available options.

## 5 CONCLUSION

The impacts of climate risks and gas flaring are well known and studied, however, finding solutions to the challenges has remained both debatable and unrealistic. Whilst many theories and ideologies of risks and management surround proposed climate risks management methodologies, the need to propose a unified approach have met with several failure. Gas flaring operation, the threats of climate risks and the vagaries of climate risks management approaches for the Niger Delta region of Nigeria has been reviewed in this paper. First of all, it is important to note that whilst there can never be a thorough elimination of climate risks, any attempts to systematically model it would potentially create another risk (risk homeostasis). To enable sustainable environmental management, the assumption and preference of conceptual management of climate risks as opposed to systematic methods which are generally phantasms, is ideal. Through this review, the adaptive environmental management approaches which suggests living with climate risks through its identification and evaluation of the severity, vulnerability, frequency and scale is strongly supported.

Clearly, gas flaring constitutes climate risks in the Niger Delta regions of Nigeria and causes a number of health conditions such as: noise and air pollution, increase in atmospheric temperature, acid rain, roof corrosion and respiratory diseases. The extent of human vulnerability to these conditions often depends on the proximity of the human settlements to the gas flaring stations. Unfortunately, much sabotage and corruption in the Nigerian petroleum industry as reviewed in the paper are serious matters that constrain efforts towards addressing human vulnerability to the environmental effects of gas flaring and climate risks in the study area.

Finally, this paper is limited to theoretical discussions on



climate risks and gas flaring in the Niger Delta region of Nigeria. It will serve as a working document to inform decisions towards addressing the issues of gas flaring in the Niger Delta regions of Nigeria as well climate risks management in Nigeria as a whole. However, we recommend for future studies the need to carry out some empirical analyses and assessment of human vulnerability to the adverse effects of gas flaring. Specifically, supposing quality data were available, we recommend that proximity to gas flaring station be estimated, analysed and mapped, since it has been pointed out as a predisposing factor with regards to human vulnerability to climate risks and the adverse effects of gas flaring.

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