

Oil spillage and gas flaring in the Niger Delta region

A systematic literature review

Evelien Heesterbeek

5915724

Supervisor: Leontien Kraaijeveld

Second reader: Floris van den Berg

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0. Summary

The aim of this systematic literature review is to determine the causes, and environmental and social impacts of oil refineries in terms of oil spillage and gas flaring in the Niger Delta region. A meta-analysis is conducted in order to determine the amount of oil spilled in the Niger Delta region annually. This is a necessity due to the lack of transparency of organisations and corporations regarding the total amount of oil spills in the region. Furthermore, it provides the basis for establishing the environmental damage and social damage caused by oil spills and gas flaring. A mix of a quantitative and qualitative research approach is used to conduct this review. However, due to a lack of quantitative data, the extent of the impacts remains unknown.

The multinational oil corporations in combination with the weak Nigerian government are the main drivers of the unsustainable process of oil extraction, and are the most to blame for the environmental degradation and the pressure on the local population in the Niger Delta region. Currently, the natural environment of the Niger Delta region suffers, among others, environmental degradation, water pollution, and soil contamination. The local communities cope with health issues, domestic and economic losses due to pollution, and polluted drinking water. This situation calls for a change.

1. Introduction

Throughout time, the need for preservation and restoration of the natural environment has rapidly increased. International regulations and agreements regarding the minimization of damage towards the natural environment have been developed. Although these regulations and agreements have been put in practice, there are still many processes continuously damaging the natural environment and livelihood of people in certain areas. One of these areas is the Niger Delta region located in Nigeria. The region consists of swampland, forests, mangroves covering about 70,000sq. kilometers, and is home to more than 10 million people of whom more than 70% is dependent on the natural environment for their livelihood (Ebegbulem et al., 2013).

For over fifty years, the region has suffered social and environmental damage due to the oil extraction processes of multinational oil companies. Oil spillage and gas flaring have resulted in serious consequences for the natural environment as well as for the local communities (Ejiba et al., 2016). Altogether, these processes have damaged the environment to the extreme, and increased the vulnerability of households leading to an uncertain and unsustainable future of the region (Ejiba et al., 2016). The occurrence of environmental and social damage is well-known, however, the damaged components are less easily recognized.

Nowadays, multinational oil companies have strict boundaries and guidelines for the extraction of oil and the amount of damage that can occur during these processes. Despite these guidelines, oil is still discharged into the local environment and multinational oil corporations continue to flare most of the obtained gas. The following question arises: *What are the causes, and social and environmental impacts of oil refineries in terms of oil spillage and gas flaring in the Niger Delta region?*

The question is answered through the use of a meta-analysis. The information needed for these reviews is based on 30 peer reviewed scientific articles. The scientific articles are based on several key indicators, i.e. sustainable development, oil spills, gas flaring, environmental damage, and social damage. The obtained data is presented in a conceptual framework to determine the relationships between the concepts. The operationalization of these concepts described in an analytical framework in order to provide a clear overview for the analysis. Furthermore, the results will be provided in two different sections, namely oil spills and gas flaring. The results are explained through the use of the peer reviewed scientific articles in combination with additional grey literature.

2. Theory

In order to provide a better understanding of the research, several theories and key concepts are described below. In addition, with the use of these theories and key concepts, a conceptual framework is provided. Lastly, an analytical framework with the focus on operationalizing these key concepts is provided.

2.1. Theory

2.1.1. Tragedy of the commons

The theory of the tragedy of the commons was founded by Garrett Hardin in 1968 and focuses on the misuse of public property and the effects hereoff on the environment and on humans (Akpomuvie & Orhioghene, 2011). The theory uses the example of sheep grazing on a pasture of land. Other herdsmen also have a flock grazing on a pasture of land. The land is currently at carrying capacity. When one herdsman adds another sheep to the pasture, overgrazing starts. This process is followed by other herdsmen wanting the same amount of profit and also adding a sheep to their flock, resulting in increased overgrazing of the land. Due to overgrazing, which results in a lack of food, the sheep begin to die. In conclusion, each herdman is pursuing his own best interest causing the common good to suffer in the proces. "Freedom in a commons brings ruin to all" (Hardin, 2009). Thus, the environment in the Niger Delta region is exploited by the multinational oil corporations due to their need for the extraction of oil. The overexploitation of this common good results in degradation of the Niger Delta region through oil spills and gas flaring causing environmental and social damage. This is seen in the current state of the Niger Delta region, which is an unsustainable and developing region.

2.2 Concepts

2.2.1. Sustainable development

Sustainable development is a broad concept and is used to describe the development regarding the unification of meeting the needs of the present without hindering future generations in the ability of meeting their own needs (United Nations, 2020). The aim of sustainable development is long-term stability of the economy and the environment. To achieve this long-term stability, aspects and concerns regarding economic growth, environmental protection, and social inclusion are integrated in the decision making process (Emas, 2015). The concept of sustainable development regarding the Niger Delta region calls for changes within the current process of oil extraction by multinational corporations.

2.2.2. Corporate social responsibility

Since the 1950s the definition of corporate social responsibility (CSR) has been changing over the decades (Carroll, 1999). Partly because of this, the theory of CSR has no established definition, but can be explained as situations in which a firm engages in actions beyond compliance. These actions appear to benefit society and go further than the interests of the firm and governmental laws than necessary (McWilliams, Siegel & Wright, 2006). CSR is composed of four obligations. These obligations are the economic responsibility, the legal responsibility, the ethical responsibility, and the philanthropic responsibility.

Firstly, economic responsibility for a corporation is to achieve the highest profit possible, to maintain a strong competitive position, and to maintain a high degree of efficiency. Performing in accordance with the expectations of the government, upholding laws, and

fulfilling a firm's legal obligations is the aim of legal responsibility. Thirdly, ethical responsibility aims for performance in accordance with the expectations of societal mores and ethical norms, and recognizing evolving ethical and moral norms adopted by society. Lastly, the aim of philanthropic responsibility is to assist voluntarily in projects that enhance the welfare of the community. A corporation's response and investment is also based on this order, meaning that the aim is to fulfill the order from top to bottom in accordance with their importance (Carroll, 1991).

Since CSR is an important part of doing business, businesses have incorporated CSR into their organizational structure. Most of the time this goes hand-in-hand with sustainability issues. Although the pursuit of maximization of the wealth of the corporation's stakeholders is important, the aim of CSR is to contribute to the wellbeing of the overarching social system of which the corporation is part (Beal, 2013).

2.2.3. Oil spillage

Since the industrial revolution, the discovery of crude oil has led to oil spillage through anthropogenic activities around the globe, affecting the earth's water, and landmass. Oil spillage has become a global issue (Kadafa, 2012). Oil spills can be divided into two groups, namely small oil spills and large oil spills. Small oil spills are more common than large oil spills, and can cause damage to the natural environment, especially in sensitive environments. Large oil spills, however, cause damage for a longer period of time, which can have environmental consequences for decades (NOAA, 2020). The areas experiencing the most severe damage from oil spills are the oil producing areas. These areas face total destruction of the natural environment and ecosystems over time. One of these regions is the Niger Delta region, which is listed as one of the five most severely damaged ecosystems due to oil spillage in the world (Kadafa, 2012).

2.2.4. Gas flaring

Crude oil is a fossil fuel located deep into the earth's crust. When crude oil is extracted, natural gas is released. When this natural gas cannot be utilized, gas flaring is used to dispose of this natural gas. In petroleum producing areas, such as the Niger Delta region, insufficient investments have been made to store or transport the gas, resulting in a high amount of gas flaring. Nigeria flares 17.2 billion m³ of gas per year in collusion with the extraction of oil (Ajugwo, 2013).

2.2.5. Environmental damage

Environmental damage, also referred to as environmental degradation, is the deterioration of the environment. Environmental damage occurs through the depletion of natural resources, the decrease in biodiversity, and through destruction of the ecosystems. The term, environmental degradation, can also be described as an undesirable change or disturbance to the environment. The primary cause of environmental damage is due to anthropological activities (Tyagi et al., 2014). Environmental damage occurs in the Niger Delta region due to oil extraction activities and oil spillings of multinational oil corporations (Ejiba et al., 2016).

2.2.6. Social damage

Negative influences on human livelihood are defined as social damage. Social damage involves negative impacts on human health (Ajugwo, 2013). Social damage also involves a negative influence on the ability of the local population to provide food and to generate an income. Most people in the Niger Delta region depend on the natural environment for subsistence and survival

(Ejiba et al., 2016). Overall, social damage compromises the current living conditions of populations, such as the local communities of the Niger Delta region.

2.3. Conceptual framework

An overview of relations between the key concepts and theories a conceptual framework is provided in figure 1.

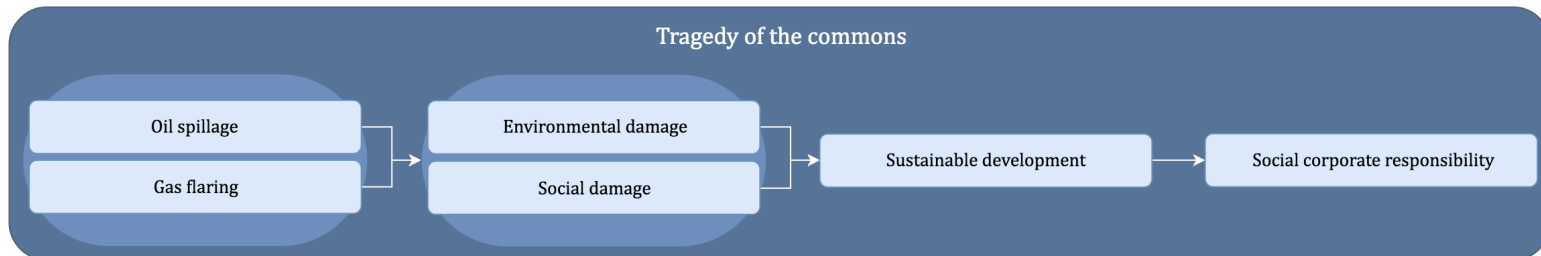


Figure 1. Visualization of key concepts and theories in a conceptual framework.

The conceptual framework starts with oil spillage and gas flaring caused by the oil refineries of multinational oil corporations. However, oil spills are also caused by the local population (Oshwofasa et al., 2012). The influence of oil spills and gas flaring on the Niger Delta region is shown in the second part of Figure 1, namely environmental damage and social damage. These concepts together result in a lack of focus on sustainable development resulting in the inability of the multinational oil corporations to achieve their social corporate responsibility goals (Ijaiya, 2014). The overarching theory in this framework is the theory of the tragedy of the commons (Hardin, 2009). The common good in this situation is the natural environment. Overexploitation of the environment by oil corporations results in degradation of the Niger Delta region, and pressure on the livelihoods of the local population (Ebegbulem et al., 2013). This is seen in the current state of the Niger Delta region, which is an unsustainable and underdeveloped region.

2.4. Analytical framework

The analytical framework gives an overview on the operationalization of the key concepts. Through the use of guidelines and determined criteria, the key concepts are put into measurable terms.

The effects of oil spillage are measured through the use of the collected quantities from peer reviewed articles. The obtained quantities are analyzed, and converted in terms of barrels oil spillage per year. The comparison between results can be simplified through the use of the converted terms. The obtained information regarding the amount of annual oil spillage is compared and cross-referenced. This overall conclusion regarding the amount of spilled oil is a necessity in order to gain insight in the current situation of the Niger Delta region. Currently, there is no consensus and a lack of transparency regarding the amount of oil spilled.

Next, the causes of oil spills are provided based on the information obtained by the peer reviewed articles. The causes are organized and visualized in a pie chart based on the frequency of mention in the studies. An explanation of the most frequently stated causes is provided.

Furthermore, the environmental damage and social damage of oil spills and gas flaring per peer-reviewed scientific article are gathered and cumulative results are provided in two bar graphs regarding the environmental damage, and two bar graphs regarding the social damage. The damage of oil spills and gas flaring are measured through the use of social and environmental guidelines. These guidelines for environmental damage are based on the

environmental impact, which is divided in several associated components. The social damage is also measured based on the different categories of social impacts. These categories and components focus on the local and regional damage. An explanation for the obtained results is provided based on the obtained information of the peer reviewed scientific articles. In some cases, the explanation consistent with the provided bar graph is expanded by additional literature based on governmental policies and grey literature.

The concept of sustainable development is not measured, since the concept is far more extensive than the conducted research will include. An indication of the severity of the overall situation in the Niger Delta region will be projected through the information obtained from the measurements and research regarding the concepts stated above. The aim of this research is to provide an overview of the current situation and a stepping stone towards sustainable development. Furthermore, the concept of CSR is not provided in measurable terms, but is discussed based on the obtained results regarding the social and environmental damage. An indication of necessary change regarding corporate sustainable development is provided.

3. Methodology

3.1. Research scope

The research question is answered through the use of a mix between a qualitative research approach and a quantitative research approach. The main focus of the conducted research is on the environmental elements of the Niger Delta region regarding the extraction of oil and the flaring of natural gas, and will therefore fall in the category of natural science. Social science is used to broaden the research regarding the social impacts and causes of the oil spills and gas flaring.

The research is solely based on Nigeria, specifically the Niger Delta region. In order to determine the extent of the damage and thus the impact of oil spills and gas flaring a systematic literature review is conducted resulting in an overview of the damage in the Niger Delta region.

3.2. A systematic literature review - meta-analysis

In order to properly assess the impacts in the Niger Delta region, a meta-analysis is conducted. A meta-analysis uses the results of a larger number of studies in order to integrate the obtained information. The analysis of the obtained independent findings results in an all-encompassing outcome. In this manner, the meta-analysis will provide structure, clarity and objectivity to the process (Rozas & Klein., 2010).

The systematic literature review is based on quantitative and qualitative data collection. The analysis consists of clear terms and concepts regarding the causes, and the environmental and social impacts of the oil spills and gas flaring in the Niger Delta region. These terms and concepts provide the basis for analysis and the systematical ordering of the obtained data. The terms and concepts are provided in Table 1.

Table 1. Terms used in the systematic literature review for the categorization of the data.

Causes of oil spills	Environmental impacts	Social impacts
Vandalism or sabotage	Environmental pollution and degradation	Disruption of cultural activities
Pipeline corrosion	Destruction of mangroves and deforestation	Loss of aesthetic value
Equipment failure	Greenhouse gas emissions	Noise disturbance
Oil bunkering	Soil/land contamination incl. loss of vegetation cover	Health effects due to water and/or oil-contaminated food
Accidents	Release of toxic heavy metals	Health effects on humans e.g. nausea, dizziness, skin irritation,

Lack of maintenance	Biodiversity loss	Human health effects due to exposure to heavy metal toxins
Human error	Habitat destruction	Economic/domestic losses from loss of traditional fishing grounds
Natural disasters	Water pollution	Economic / domestic losses from degradation of agricultural lands
Oil well blowout	Negative impact on aquatic environment	Food insecurity
Deliberate releases	Disruption of food chains	Poverty
Insufficient investment	Altered physio-chemical properties of the soil	Drinking water pollution
Unknown causes	Reduced crop productivity and plant growth	Environmental migration
	Acid rain	Unemployment
	Atmospheric pollution	Increase in violence
	Fire outbreaks	Heat exposure or thermal pollution
		(Emotional) distress or discomfort
		Permanent light from gas flames or light pollution
		Foul odour
		Direct or indirect death of humans

Peer reviewed scientific articles are used to obtain the relevant information. The search terms used are ‘effects oil extraction,’ ‘effects oil spills,’ ‘crude oil spills and human health implications,’ ‘oil spills,’ ‘gas flaring,’ ‘oil spill problems,’ and ‘oil spills and gas negative effects.’ These terms are accompanied by the term ‘Niger Delta region.’ The selection of the articles is also based on publications between the years 2000 and 2020. The final selection of the peer-reviewed scientific articles is made by reading the abstract.

3.3. Data analysis and usage

The collected data is from quantitative and qualitative origin for the systematic literature review. The thirty peer reviewed scientific articles are collected through the database, called Google Scholar. This includes references to other databases closely interlinked with Google Scholar. The collected data is coded in order to properly arrange and analyze the obtained information. The codes are ‘environmental impact of oil,’ ‘social impact of oil,’ ‘amount of oil,’ ‘reason for oil spills,’ ‘environmental impact of gas flaring,’ ‘social impacts of gas flaring,’ and ‘reason for gas flaring.’ Furthermore, the use of peer reviewed scientific articles from authors and agencies with different worldviews and biases will give the best possible objective result.

3.4. Plagiarism and fraud

Data from other authors is handled with extreme care in order to prevent plagiarism and fraud. The specific author is mentioned by name, and given the acknowledgement the researcher deserves when using the author’s data. The researcher is not passing the work of another researcher on as the work of their own. Furthermore, the research is based on existing data, and does not contain information made up by the researcher.

4. Results

The obtained results based on the systematic literature review will be provided in different sections. The first section consists of the amount of oil spilled annually. This section is followed by a section stating the causes of oil spills, followed by the environmental and social impacts of oil spillage. Lastly, the causes, and environmental and social impacts of gas flaring are provided. The results regarding the amount of oil spilled in the Niger Delta region consists of 9 different sources. The results regarding social and environmental impacts of oil spillage and gas flaring are based on thirty peer reviewed scientific articles in accordance with the set guidelines of

Table 1. Furthermore, the more extensive used guidelines are shown in the Appendix on page 23.

4.1. Oil spills

4.1.1. Amount of spilled oil

The amount of spilled oil in the Niger Delta region on annual basis differences per source. The lack of consensus regarding the amount of oil spilled leads to an uncertainty regarding the actual situation in this area. Furthermore, multinational oil companies located and operating in the Niger Delta region often undervalue the amount of an oil spill. A large number of oil spills are not reported or go undetected (Ite et al., 2013). Other factors contributing to the underestimation of the oil spills are a the location of the spill, a difficulty in access or security concerns limiting the access, a large time difference between the spill and the detection causing a large amount to evaporate before being measured, and the intentional underreporting of oil spills by the government and multinational oil companies (Ordinioha, & Brisibe, 2013). The amount of oil that is actually spilled in the Niger Delta region could be ten times as high as reported (Ite et al., 2013). An overview of reported annual amounts of oil spillage by different organizations, studies, and scholars is provided in Figure 2.

Amount of spilled oil on annual basis

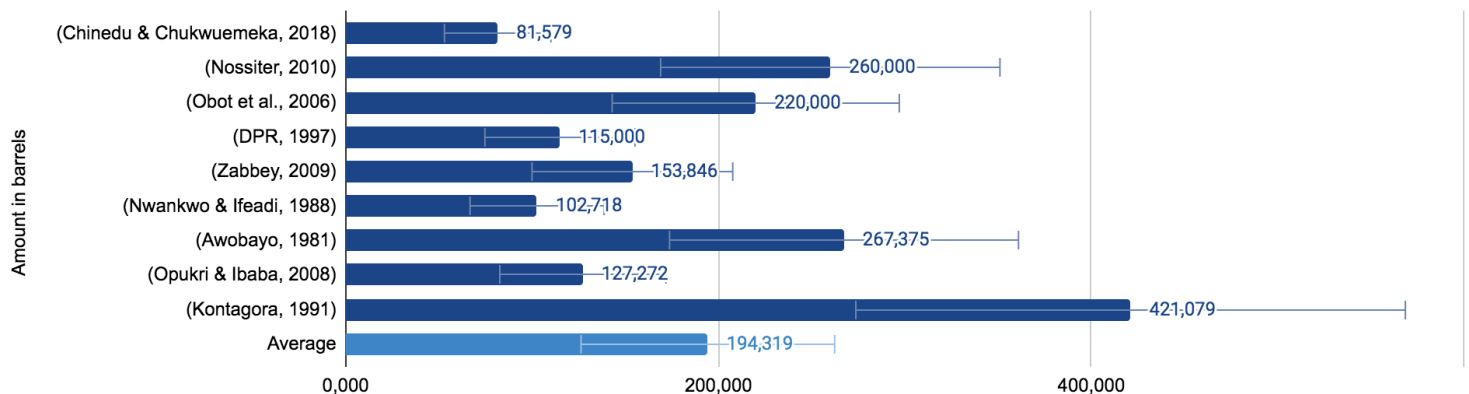


Figure 2. The amount of oil spilled (in barrels) on an annual basis in the Niger Delta region

The results in Figure 2 are based on the amount of oil spilled over a certain amount of years between 1958 and 2014. The shortest measuring period was four years and the longest period was 50 years. The total amount of oil spillage is divided by the corresponding amount of years, and is rewritten in terms of annual oil spillage. The amount of oil spilled is provided in the number of barrels per year. The average of ten initial resources is 194,319 barrels per year with a standard deviation of 107581.9. Furthermore, the margin of error based on the ten obtained results is roughly 35% as shown in Figure 2.

The National Oil Spill Detection & Response Agency (NOSDRA) in Nigeria is an institutional framework and one of the most prominent agencies regarding the control and measurement of oil spills in the Niger Delta region. This agency measures an annual amount of 48,272 barrels of oil spilled in the Niger Delta region (NOSM, 2019; NOSDRA, 2021). The results from the NOSDRA again vary enormously in relation to the stated results in Figure 2. Furthermore, the amount of unrecovered spilled oil in the environment is 70-77% (Kadafa, 2012).

4.1.2. Causes

According to Chinedu and Chukwuemeka (2018) the Niger Delta region experiences the highest rate of oil spills in Nigeria. The different causes of oil spills have been present in 17 of the 30 peer reviewed scientific articles used in the systematic literature review. The amount of causes for oil spills per article is variable. The total amount of causes provided by the seventeen articles is 74. The percentages of the frequency of the causes of oil spills mentioned, are provided in figure 3.

Causes of oil spills

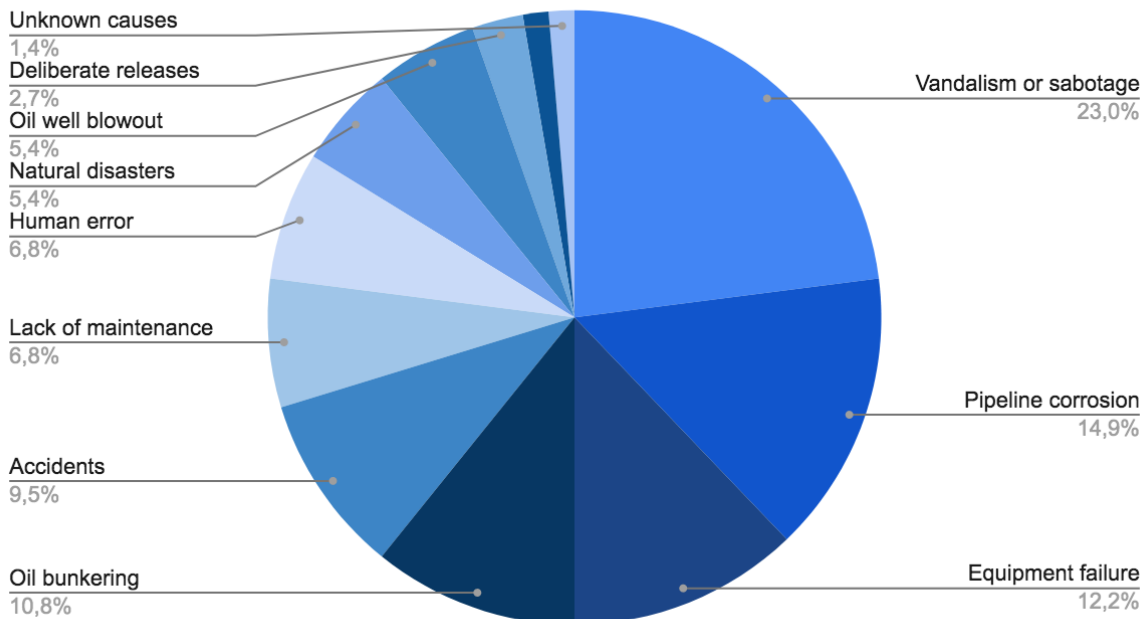


Figure 3. The causes of oil spills.

The most commonly stated causes of oil spills are vandalism or sabotage, pipeline corrosion, and equipment failure as shown in Figure 3. The remaining eight causes are less frequently mentioned in the peer-reviewed scientific articles as shown by the percentages in Figure 3.

The current living conditions of the local population in combination with the large profits the multinational oil corporations and the Nigerian government obtains is cause for restiveness among the local communities. This restiveness is most common among the local youth. They express their restiveness and their need for justice through acts of abduction and hostage-taking, but mostly through sabotage against the multinational oil corporations. This motive, coupled with other social and environmental factors, has caused increased pressure on the health of the environment (Oshwofasa et al., 2012).

Furthermore, the network of pipelines and flowlines in the Niger Delta region consist of over 7,000 kilometers, and includes 275 flowstations and is home to over thirteen oil companies (Ebegbulem et al., 2013). The lack of inspection of the pipelines in combination with the old age of the pipelines makes them susceptible to corrosion resulting in a multitude of oil spills. Most of the currently used pipelines are over 50 years old and lack the current standards for pipelines. The original pipelines were expected to have a lifespan of approximately fifteen years (Emoyan, 2008). The pipelines are besides corrosion also affected by vandalism.

Equipment failure resulting in oil spills can be due a defect or due to neglect or due to the impacts of the natural environment. A defect in equipment can be due to a defective design

or due to a manufacturing defect. Equipment neglect resulting in equipment failure is among others based on improper use of the equipment, inadequate maintenance, infrequent safety inspections, or inadequate training. Furthermore equipment failure can also occur due to corrosion or metal fatigue (Stipe Law, 2017).

During the process of oil bunkering performed by the local population, the pipelines are damaged and destroyed in order to siphon the oil (Aroh et al., 2010). Accidents, lack of maintenance, human error, natural disasters, oil well blowout, and deliberate releases are less commonly mentioned in the peer-reviewed articles as shown in Figure 3, but are an important part of the enormous amount of oil spilled on a yearly basis in the Niger Delta region.

4.1.3. Environmental impacts

The environmental impacts of oil spills are shown in Figure 4.

Environmental impacts of oil spills

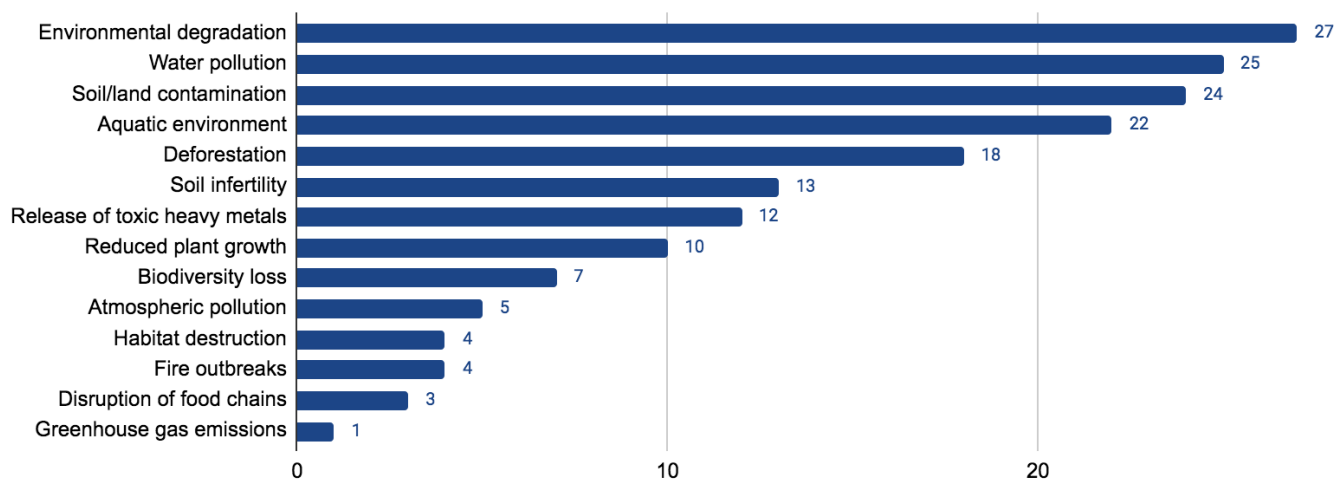


Figure 4. The frequency of occurrence of the environmental impacts caused by oil spills in the Niger Delta region.

The most frequently stated environmental impacts of oil spills are environmental degradation, water pollution, soil and/or land contamination, and a negative impact on the aquatic environment. Other frequently stated environmental impacts of oil spills are deforestation, soil infertility, the release of heavy metals, and reduced plant growth as shown in Figure 4.

The exploration and exploitation of crude oil in the Niger Delta region comes with environmental degradation. Environmental degradation is seen as the greatest negative tendency of oil exploration and exploitation (Ebegbulem et al., 2013). Environmental degradation is mentioned in 27 out of 30 peer-reviewed scientific articles, and can thus be seen as the largest impact of oil spills. Environmental degradation is a major issue for the communities in the Niger Delta region due to the negatively affected productivity resulting in food insecurity. It also results in a loss of economic empowerment, which causes poverty (Elum et al., 2016). These social consequences of environmental degradation are stated in Figure 5 below.

Crude oil contains polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and also contains heavy (toxic) metals (Ajugwo, 2013; Obida et al., 2018). The toxicity is dependent on the type of crude oil, the level of oil contamination, the kind of environment, and the sensitivity of the organism towards the particular type of crude oil (Ugochukwu & Ertel,

2008). Nevertheless, during an oil spill these chemicals, organic compounds, and heavy metals are released in the environment, thereby polluting the water and contaminating the soil.

Soil contamination is mainly due to the posing of soils and sediments as sinks for petroleum contaminants. Petroleum contamination entails a certain toxicity level depending on the external environmental properties, and its components have a refractory character in absence of oxygen (Ite et al., 2013). Additionally, soil contamination resulting from oil spills causes the physico-chemical properties of the soil to be altered. This alteration causes the soil fertility to decline, the plant growth to diminish, and the crop productivity to reduce (Onyena, & Sam, 2020).

The contamination of the soil in combination with poor land management has caused forests to diminish. The deforestation in the Niger Delta region is caused by the constant pollution from oil refineries, and especially from oil spills. The volatile, quickly penetrating, and viscous properties of the oil have caused a loss of vegetation cover in extending areas. This process is accelerated in areas close to oil-polluted brackish water bodies. The combination of the force of the river and the force of the tides cause spilled oil to spread further into areas with vegetation (Adelana et al., 2011).

Furthermore, oil spills result in oil slick on the water surface causing the water to be unable to obtain the oxygen from the air. The oil slick in combination with the presence of toxic heavy metals and the reduction of nutrients in the water, results in an uninhabitable environment for aquatic organisms (Aghalino & Eyinla, 2009). Aquatic organisms are thus affected by physical contamination, and bio-accumulation, but are also affected by the loss of habitat and spawning grounds caused by oil spills (Ejiba et al., 2016).

4.1.4. Social impacts

The social impacts of oil spills are stated in Figure 5.

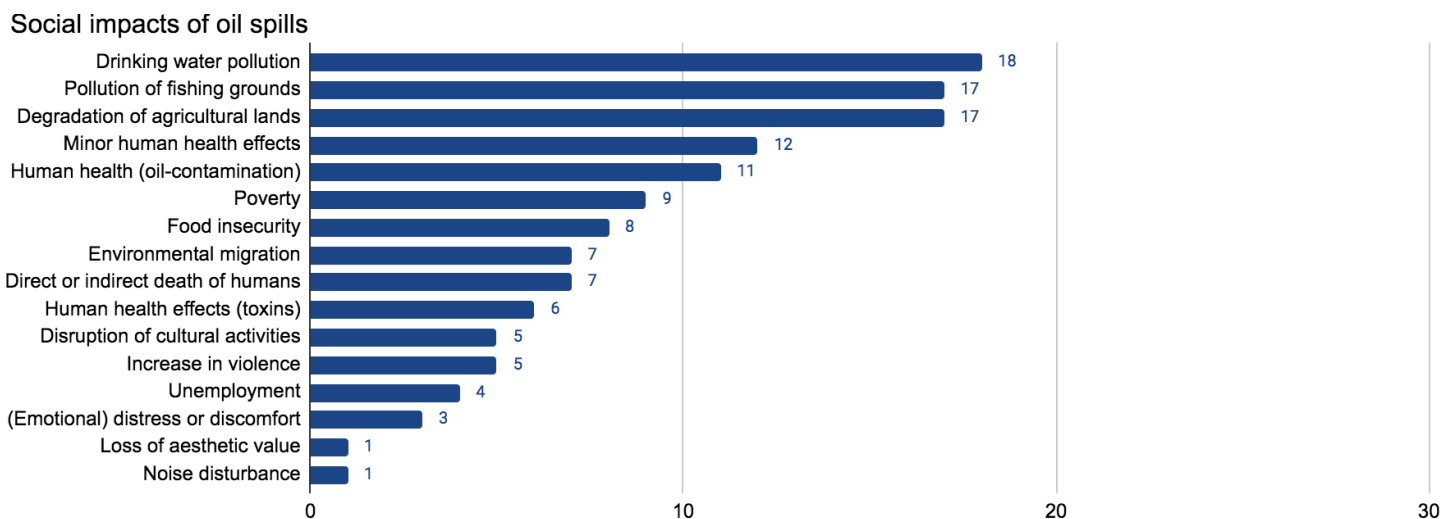


Figure 5. The frequency of occurrence of the social impacts caused by oil spills in the Niger Delta region.

The most frequently stated social effects of oil spills are drinking water pollution, and the economic and/or domestic losses from degradation of agricultural lands and traditional fishing grounds as shown in Figure X. Other effects are minor human health effects i.e. nausea, dizziness, diarrhea, skin irritation, and respiratory ailments, and human health effects caused by the consumption of oil contaminated water or food as shown in Figure 5.

As previously mentioned, crude oil contains PAHs, VOCs, and heavy metals (Obida et al., 2018; Ajugwo, 2013). When an oil spill occurs, these chemicals, compounds, and heavy metals are released in the natural environment. An oil spill therefore contaminates the water used for drinking and other domestic purposes in the oil producing areas. This affects the livelihood negatively, especially since most of the affected people are already living in poor areas. These impoverished residents rely on traditional fishing grounds to provide food and water for themselves. They also rely on agricultural lands for food production (Baghebo et al., 2012). These agricultural lands are also greatly affected by oil spills on land as well as on water. Depending on the severity of the spill, the affected land influenced the soil stability resulting in reduced crop growth and productivity for the farmers in the Niger Delta region (Ejiba et al., 2016). The losses of traditional fishing grounds and agricultural lands serve as economic as well as domestic losses for the local community, which eventually results in poverty (Baghebo et al., 2012; Oyebamiji & Mba, 2014).

Oil spills can influence human health through physical exposure, and through pressure on mental health. Physical exposure occurs through the consumption of oil contaminated food or water, and through skin contact. The contamination of food occurs when humans eat food crops grown on polluted soil or eat aquatic organisms from contaminated water (Nriagu et al., 2016). Fish, for example, consume the biotoxins from the oil polluted water. These biotoxins accumulate in the fish, which are in turn consumed by humans, resulting in hazardous health effects, i.e. asthmatic attacks, headache, diarrhea, dizziness, abdominal pain, and other symptoms (Onyena, & Sam, 2020). Furthermore, the mental health is subject to the sensation of risk, worry, and chronic stress. Physiological health consequences of exposure to oil spills and oil pollution can result in physical utterances, i.e. abnormalities regarding hematologic, hepatic, respiratory, renal, and neurological functions (Nriagu et al., 2016).

4.2. Gas flaring

4.2.1. Causes

The exploitation of crude oil started in 1958. At this time, there were no regulations and policies put in place regarding the exploitation, production, and usage of natural gas. At that point in time, the production of crude oil was the priority even though the gas reserves of the Niger Delta region were twice the amount of oil reserves (Oyewunmi, & Oyewunmi, 2016).

Nowadays, gas flaring in the Niger Delta region has been ruled a violation of human rights by the Nigeria courts in 2005. However, oil companies still continue the flaring of gas (Elum et al., 2016). Nigeria flares around 76% of their gas, and has the highest gas flaring rates on global scale (Ologunorisa, 2001). This is mainly due to the weak enforcement of policies and regulations by the authorities resulting in non-compliant multinational oil corporations (Oyewunmi, & Oyewunmi, 2016). Furthermore, the focus of Nigerian government regarding the oil industry is mainly on the maximization of its monetary profits from oil production. This particular focus on oil production causes the Nigerian government approximately 2.5 billion dollars in revenues on an annual basis due to gas flaring (Ajugwo, 2013).

The multinational oil corporations perceive the consequences of gas flaring, which is contrary to the regulations, as insignificant (Oyewunmi, & Oyewunmi, 2016). From an economic perspective, the flaring of natural gas including the payment of the additional fine is more profitable than reinjection of the gas back into the oil wells (Ajugwo, 2013). Collecting the natural gas and turning it into a profitable byproduct is according to the multinational oil corporation no option. This is due to the lack of infrastructure and the insufficient energy

market, especially in the rural areas (Ajugwo, 2013; Kadafa, 2012). Thus, gas flaring is seen as a negative operational externality of oil production by multinational oil corporations (Oyewunmi, & Oyewunmi, 2016).

The economic perspective of multinational oil corporations on gas flaring causes human health and the environment often to be of secondary consideration. As for the Nigerian government, the economic and political satisfaction are of more importance than the damaging consequences to the environment and human health (Ajugwo, 2013). The main reasons for the importance of the economic sector and the political sector are due to Nigeria's weak institutional arrangements, poor regulation, and official corruption. These governmental reasons in turn provide the multinational oil corporations with ways to take advantage of the system (Ejiba et al., 2016).

4.2.2. Environmental impacts

The environmental impacts of gas flaring are stated in Figure 6.

Environmental impacts of gas flaring

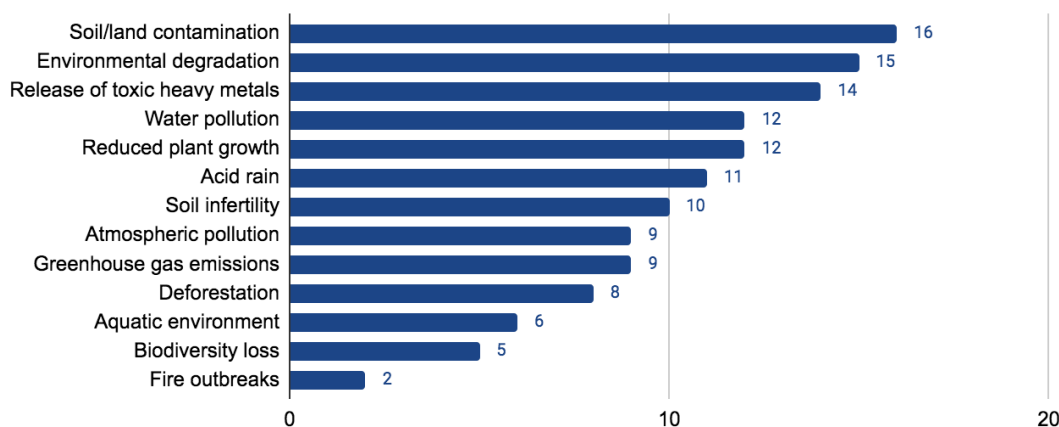


Figure 6. The frequency of occurrence of the environmental impacts caused by gas flaring in the Niger Delta region.

The result of gas flaring throughout the years has been major environmental degradation of the Niger Delta region (Elum et al., 2016). This can be seen in Figure 6. Other frequently stated environmental impacts of gas are the contamination of the soil, the release of heavy metals, water pollution, reduced plant growth and acid rain.

The environmental degradation of the Niger Delta region due to oil extraction processes is enhanced by the release of greenhouse gases through gas flaring (Seiyaboh & Izah, 2017). These greenhouse gases are contributors to global warming resulting in climate change (Elum et al., 2016). The flaring of natural gas also includes the release of pollutant gases into the atmosphere. The released pollutant gases are nitrogen dioxides, sulphur dioxide, volatile organic compounds (including carcinogens and air toxins), particulates, toxic heavy metals, and black carbon soot. These gases contribute to atmospheric pollution (Ite et al., 2013; Seiyaboh & Izah, 2017).

Furthermore, gas flaring results in the contamination of soil and/or land. The soil contamination in Figure 6 includes the loss of vegetation cover (see Appendix on page X). The soil surrounding the gas flaring sites are the most contaminated and affected. The tremendous heat of the flare site in combination with a relatively acid soil pH causes vegetation in the surrounding environment to be unable to grow. The soil near the gas flaring site has a general pH of below 5.6 resulting in the depletion of naturally occurring soil nutrients (Ajugwo, 2013;

Ubani & Onyejekwe, 2013). The influence of the flare on the state of the soil also includes an increase in soil temperature with the highest soil temperature the closest to the flare and the moisture content in the soil with the lowest moisture content closest to the flare site. The acidity, temperature, and moisture content of the soil also influences the agricultural sites in the surrounding area (Ubani & Onyejekwe, 2013). Another contributor to soil contamination and poor agricultural yields is the relatively high ratio of polycyclic aromatic hydrocarbons in the soil (Ite et al., 2013). In conclusion, the physio-chemical properties of the soil have been altered resulting in low crop yield and loss of soil fertility.

Gas flaring sites alter the quality of surface water, ground water, and rain water, thereby affecting aquatic organisms. The water contains a higher concentration of metals, i.e. barium,, cyanide, selenium, cadmium, chromium, iron, manganese, and copper. The color and taste from water close to flare sites also differs compared to water in a non-flaring area. The increased temperature, and the accumulation of dissolved salts and other organic materials in the water cause an increase in water conductivity, thereby affecting the quality of the water (Seiyaboh & Izah, 2017). The water quality is also affected by acid rain. Acid rain is caused by gas flaring due to the release of sulphur emissions and carbon dioxide emissions, which combined with atmospheric moisture result in sulfuric acid and nitric acid respectively (Ajugwo, 2013; Elum et al., 2016). The water in the Niger Delta region has become more acidic due to the relatively regular occurrence of acid rain in the region compared to non-flaring regions (Ejiba et al., 2016; Ubani & Onyejekwe, 2013). Acid rain is also the reason behind the acidification of the soil as mentioned above. Soil acidification results in a loss in biodiversity, the destruction of forests, and reduced crop growth and productivity (Ejiba et al., 2016). The concentration of acid rain decreases the further away from the Niger Delta region (Kadafa, 2012).

4.2.3. Social impacts

The social impacts of gas flaring are shown in Figure 7.

Social impacts of gas flaring

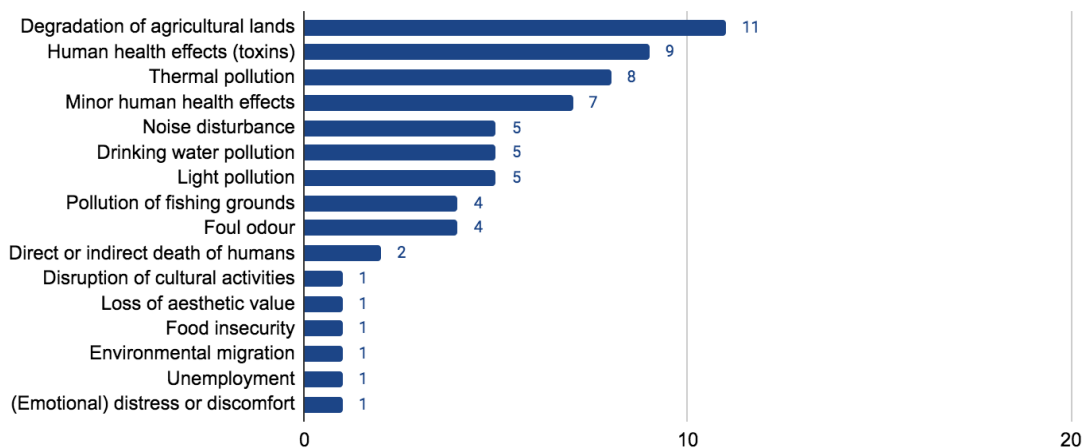


Figure 7. The frequency of occurrence of the social impacts caused by gas flaring in the Niger Delta region.

Degradation of agricultural lands, human health effects caused by toxins, thermal pollution, and minor human health effects are most frequently stated. Noise pollution, drinking water pollution, and light pollution are also regularly mentioned in the articles as seen in Figure 7.

The impacts of gas flaring on the soil and the agricultural lands have been explained in the previous section. The damage to the agricultural lands resulting in loss of crop productivity and soil infertility have a negative impact on the local farmers. The local farmers are thus

affected by gas flaring, and suffer economic and domestic losses from degradation of their agricultural lands (Ubani & Onyejekwe, 2013). Moreover, the local communities also suffer from thermal pollution, noise disturbance, light pollution, and foul odour as shown in Figure 7. Gas flaring sites are often close to local communities, thereby lacking protection of the communities against exposure (Nriagu et al., 2016). The generated amount of heat, foul odour, and noise is observed and perceived by the local community as far as hundreds of metres away from the gas flaring site (Oyewunmi, & Oyewunmi, 2016). Most gas flaring sites continue for 24 hours a day, which results in the subjection of the local population to continuous noise disturbance and light pollution. The results of the combined exposure of the local population to noise pollution, foul odour, thermal pollution, and permanent light, in combination with black smoke from the gas flaring site is no good for anyone's health (Nriagu et al., 2016).

Furthermore, the local community is affected by the hazardous air pollutants and heavy toxic metals released during the flaring of gas causing unfavourable health impacts, i.e. kidney disease, cancer (among which leukemia), neurological effects, reproductive effects, developmental effects, anemia, pancytopenia, and potential death (Ajugwo, 2013; Kadafa, 2012). The gases released during the flaring of natural gas also cause minor health impacts, i.e. skin rashes, bronchial diseases, and respiratory ailments, which are the consequences of long term gas exposure (Oshwofasa et al., 2012).

Gas flaring results in the contamination of water bodies in the Niger Delta region. The acidification and thereby the contamination of the water bodies region puts pressure on the livelihood of the local communities. The water bodies the local population uses for domestic purposes, especially for drinking water, are polluted and contaminated (Emoyan, 2008). It also affects the survival of fishes and other aquatic organisms (Ubani & Onyejekwe, 2013). The aquatic organisms that survive migrate from in-shore or shallow waters to the deep sea. The depletion of the fishing resources in the Niger Delta region resulting in a shortage of food, and can even lead to the inability of the local population to meet the basic needs (Onyena & Sam, 2020).

Lastly, the World Health Organization has stated that the flaring of natural gas on a global scale contributed to the direct or indirect death of 2.5 million people on an annual basis. This is similar to 4-5% of the total annual deaths on earth (Raji & Abejide, 2013).

5. Discussion

The theory of the tragedy of the commons based on the inability of sharing a common resource is seen in the Niger Delta region (Hardin, 2009). In the case of the oil exploitation in the Niger Delta region the common resource as meant by this theory is the natural environment. The main goal of the multinational oil corporations is to gain monetary value through oil extraction and gas flaring at the expense of the natural environment resulting in a negative impact on the local communities (Ajugwo, 2013). The carrying capacity of the environment as described by the theory of the tragedy of the commons has been exceeded. The theory is supported by the results and shows the current process of environmental degradation causing devastating environmental damage and social damage.

The environmental damage is measured as environmental impacts in this review, which leaves the ability to control the actual value of the results, and the extent of its contribution to the environment. Other factors and measurements could be incorporated in the analysis in order to provide a better understanding of the overall situation in the Niger Delta region. These factors and measurements need to be complementary to the already provided results. The same question of completeness of the results regarding the social damage arises. The results do

provide a good overview of the current situation, but could be complemented by quantitative results regarding the numerical amounts of environmental and social damage.

Furthermore, the systematic literature review through the use of a meta-analysis is prone to miscalculations. The statistical summaries and other necessary calculations needed to the meta-analyst to perform the analysis are often not provided fully in the original publications. The data needed to perform the calculations is presented in the original publications, and must be assessed and gathered before the data can be used for the meta-analysis. These recalculations can potentially lead to calculation errors (Rozas & Klein, 2010). Another potential problem that can occur during a meta-analysis is the inclusion of the same data multiple times in the analysis. This is due to the possibility that one study may be reported several times in the research literature, and therefore the possibility of the same data or parts of the same data being present in different scientific research papers exists (Davies, 2000).

As for the results, these are based on thirty peer reviewed scientific articles, which are selected through the use of several research criteria. The results that show a high frequency of mentioning by the studies can be adopted with a high degree of certainty as consequences of oil spills and gas flaring. However, the impacts of oil spills and gas flaring with a low mentioning frequency have a relatively low degree of certainty and should not be adopted as well-known environmental and social impacts without further exploration or additional research. Besides the validity of the results, some of the scientific articles used in the meta-analysis provide uncertainties within themselves. These uncertainties are not based on the occurrence of the phenomena themselves, but regard to the extent of these phenomena. The results of this analysis are not influenced by these uncertainties, but it is important to keep this in mind while interpreting the social and environmental impacts.

One of these uncertainties is whether or not a particular oil spill is due to sabotage and vandalism, or caused by another phenomenon. The lack of transparency from governmental organizations, environmental organizations, and multinational oil corporations has caused no consensus regarding the cause of certain spills. According to the Department of Petroleum Resources in 2014, 65% of the oil spills were caused by sabotage and vandalism. Multinational oil corporations on the other hand argue that this is most likely around 90% (Ejiba et al., 2016). Scholars argue that oil spills caused by sabotage and vandalism are due to civil unrest and disaffection resulting from the current political process (Nwilo & Badejo, 2005). Others argue that sabotage and vandalism by the local population is in order to claim compensation from the multinational oil companies (Aroh et al., 2010). Sabotage and vandalism can also arise from criminal activity fostered by the Nigerian state and nurtured by oil companies (Ite et al., 2013; Oshwofasa et al., 2012). Another extensive analysis is required in order to obtain insight in the causes of these oil spills and the reason behind them.

Furthermore, the CSR of the multinational oil corporations towards the environment and the local population should require the corporations to aim for sustainable development. As long as the multinational oil corporations continue the extraction of fossil fuels in the Niger Delta region, the achievement of sustainable productivity and thereby sustainable development is not possible (Ijaiya, 2014). However, multinational oil corporations could minimize the corresponding oil spills and gas flaring processes in order to take a step in the right direction. The reinjection of gas into the ground or the closure of extraction facilities in which gas flaring occurs could be set as a requirement by the multinational oil corporations or the Nigerian government (Ajugwo, 2013).

In the future, the lack of incentive by the Nigerian government to uphold and enforce their environmental policies and regulations needs to change. Support by the Nigerian

government for the rights of the local population needs to be implemented. In addition, the multinational oil corporations need to strengthen their commitment and fulfill their set goals regarding social corporate responsibility. Based on the four obligations related to social corporate responsibility, multinational oil corporations can start with including legal responsibility to their already substantial economic responsibility. The corporations are promoting their commitment towards their ethical and philanthropic responsibility, while in practise, these commitments are not being executed. Measuring up to the four obligations of CSR should no longer be seen as optional and non-obligatory by the multinational oil corporations. A change in the current management of CSR would be beneficial for the environment and the local communities in the Niger Delta region (Ijaiya, 2014).

6. Conclusion

This analysis provides the answer to the causes, and environmental and social impacts of oil spills and gas flaring in the Niger Delta region to the best of its ability. Based on the results obtained by the analysis, the annual total of spilled oil to be 186,734 barrels on average. The main causes of the oil spills based on the frequency of occurrence of the scientific articles is vandalism and sabotage by the local population, pipeline corrosion due to the old age of the pipelines, and equipment failure either due to defects or due to neglect by the multinational oil corporations. Studies show that the main causes for gas flaring are mostly due to the weak enforcement of policies and regulations by the Nigerian government and the additional level of corruption. The multinational oil corporations aim to achieve the highest monetary profits and consider the natural and social environmental damage to be secondary.

The data suggests that the most prominent environmental impacts resulting from oil spills are environmental degradation, water pollution, soil contamination, negative influence on the aquatic environment, deforestation, soil infertility, the release of heavy metals, and reduced plant growth. The most noteworthy environmental impacts due to gas flaring are also environmental degradation, soil contamination, the release of heavy metals, water pollution, reduced plant growth and acid rain. Since oil spills as well as gas flaring have several similar impacts, it can be concluded that both gas flaring and oil spills contribute to these processes, and the combination of both at the same location enhances the overall degradation of the natural environment.

Furthermore, the data implies that the most outstanding social impacts of oil spills are drinking water pollution, degradation of agricultural land and pollution of the traditional fishing grounds resulting in economic and domestic losses, and health effects. The data states the most called upon social impacts of gas flaring to be degradation of agricultural lands, human health effects, thermal pollution, noise pollution, drinking water pollution, and light pollution. Again, some of these results are overlapping. Thus, both oil spills and gas flaring contribute to similar social impacts, and some impacts are solely the result of either oil spills or gas flaring.

It can be concluded that the environmental impacts result in the social impacts causing the local population to migrate due to the inability of self-provisioning. Another result of these processes is the biodiversity loss, and even human death. The oil spills and gas flaring processes and the continued productivity of the oil refineries result in an unsustainable developing region. The Niger Delta region is and continues to rapidly deteriorate and degrade.

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8. Appendix

Article (author and year)	Year	Amount of oil spills (annually)	Causes of oil spills	Environmental impacts of oil spills	Social impacts of oil spills	Environmental impacts of gas flaring	Social impacts of gas flaring
Onyena & Sam	2020			A, B, D, E, F, G, H, I, J, K, L	A, B, C, D, E, F, G, H, I, J, K	A, B, C, D, H, I, L, M	E, F, G, H
Chinedu & Chukwuemeka	2018	1976-2014 - 3.1 million barrels	A, D, E, F, H	A, B, D, E, H, I, K	D, E, F, K		
Albert et al.	2018	Over 50 years - 9-13 million barrels		A, B, F, G, H, I, N	D, E, L, J, M, N		
Obida et al.	2018	1958-2010 - 13 million barrels	A, F, K	A, B, C, D, F, G, H, I, K, L	D, J, E, F, K, G, H, I	N	
Seiyaboh & Izah	2017			A, D, H, N		B, D, E, H, I, M, K, L	C, E, F, K, O
Nriagu et al.	2016	Over 50 years - 9-13 million barrels	A, B, D, F, G, I	A	D, E, F, G, H, K, P	N	C, E, F, O, Q, R
Elum et al.	2016	1976-1996 - 2,369,470 barrels	A, B, F	A, D, E, H, I, K, N, O	G, H, I, J, K, S	C, D, H, M, N	A, K
Oyewunmi & Oyewunmi	2016					A, C, E, F	C, O, R
Ejiba et al.	2016	1976-2001 - 115,000 barrels/y	A, B, C, G, H, L	A, B, D, H, I, K, L	G, H, K	A, B, D, E, F, M, N, L	G, H
Oyebamiji & Mba	2014	1970-1982 - 2 million barrels	A, B, C, D, E	A, B, D, G, H, I, K	A, D, E, G, H, I, J, K, L, N, S		
Raji & Abejide	2013	1976 - 1996 4,835 barrels of oil annually	A, B, C, G, I	A, B, H		A, D, E, H, K, L, M, N	F, H, Q, O, S
Ubani & Onyejekwe	2013					A, C, D, E, H, I, K, M	C, H, K, O, Q
Ordinioha & Brisibe	2013	Over 50 years - 13 million barrels		A, B, D, E, H, K, L	K, I, D, E, F		
Ite et al.	2013	1976-2000 - 2,567,966 barrels Over 50 years - 9-13 million	A, C, D, E, J	A, B, D, E, H, I	E, F, G, H, K	A, D, E, H, I, L, N	
Ajugwo	2013			B, D	G, H	A, C, D, E, H, K, L, M, N	F, G, H
Ebegbulem et al.	2013	1976 - 1996 - 2,446,322 barrels		A, D, H, I	G, H, J, K, M	A, D, E, H, K, L, N	H, K
Kadafa	2012	Over 50 years - 9-13 million barrels 1976-1996 - 2,369,470 barrels		A, D, H, I	G, H, K	A, B, C, D, E, F, H, K, L, O	E, F, K, M, O, S
Oshwofasa et al.	2012		A	A, B, D, E, H, I, J, K, L, N		A, D, K, L, E, M	E, F, Q
Baghebo et al.	2012	1976-1990 - 2,105,393 barrels	A, C	A, B, D, H, I, K, L	D, G, H, K, S	A, B, C, D, E, K, L, N	B, H, Q, R
Akpomuvie & Orhioghene	2011	1970-1982 - 1.67 million barrels	A, B, C	A, D, F, H, I	G, H, N, L	A, C, M	E, F
Adelana et al.	2011	1976-1996 - 1.89 million barrels	A, B, C, D, G, H	A, B, D, E, H, I	A, E, I, K, M, S		
Egbe & Thompson	2010	1976-1996 - 2,369,470 barrels	A, D, E, F, H	A, D, E, H, I, K, L	D, E, G, H, I, J, K, L		
Aroh et al.	2010	1976-8190 - 1,336,875 barrels 1976-1990 - 2,105,393 barrels 1976-1998 - 2,571,113.90 barrels	A, B, C, D, G, H	A, D, F, H, I, N, O	D, E, G, H, K, L, P, S		

Aghalino & Eyinla	2009		B, I	A, B, D, E, H, I, K, L, O	D, K		
Ugochukwu & Ertel	2008	1976-1997 - 2.8 million barrels		A, B, D, E, F, H, I, J, L	G, H	B, D, F, H, O	
Opukri & Ibaba	2008	1976-1990 - 2,105,393 barrels	A, C	A, B, D, H, I, K, L, O	G, H, J, L, N	A, B, D, K, L	H
Emoyan	2008	2.3 million cubic metres /y	A, B, E	A, B, D, E, F, H, I	K	C, D, E, H, I, L, M	G, H, O
Nwilo & Badejo	2005	1976-1996 - 2,369,470 barrels	A, B, E, I, J	A, B, D, H, I	A, H, K, L, P		
Onwuka	2005			A, D, E, H, I, K	G, I, J, M	A, D, E, H, I, K	H, I
Ologunorisa	2001			A		A, B, E, F, I, M	C, E, F, H, L, O, P, R

Causes of oil spills

- A. Vandalism or sabotage
- B. Pipeline corrosion
- C. Equipment failure
- D. Oil bunkering
- E. Accidents
- F. Lack of maintenance
- G. Human error
- H. Natural disasters
- I. Oil well blowout
- J. Deliberate releases
- K. Insufficient investment
- L. Unknown causes

Environmental impacts

- A. Environmental pollution and degradation
- B. Destruction of mangroves and deforestation
- C. Greenhouse gas emissions including damage to the ozone layer
- D. Soil/land contamination and destruction including loss of vegetation cover
- E. Release of toxic heavy metals
- F. Biodiversity loss
- G. Habitat destruction
- H. Water pollution
- I. Negative impact on aquatic environment
- J. Disruption of food chains
- K. Altered physio-chemical properties of the soil (causing soil infertility)
- L. Reduced crop productivity and plant growth

- M. Acid rain
- N. Atmospheric pollution
- O. Fire outbreaks

Social impacts

- A. Disruption of cultural activities
- B. Loss of aesthetic value
- C. Noise disturbance
- D. Health effects due to water and/or oil-contaminated food
- E. Health effects on humans e.g. nausea, dizziness, diarrhea, skin irritation, respiratory ailments
- F. Human health effects due to exposure to heavy metal toxins e.g. carcinogenic effects, organ failure, child deformities
- G. Economic and/or domestic losses from pollution of traditional fishing grounds
- H. Economic and/or domestic losses from degradation of agricultural lands
- I. Food insecurity
- J. Poverty
- K. Drinking water pollution
- L. Environmental migration
- M. Unemployment
- N. Increase in violence
- O. Heat exposure or thermal pollution
- P. (Emotional) distress or discomfort
- Q. Permanent light from gas flames or light pollution
- R. Foul odour
- S. Direct or indirect death of humans