“FLOODING OIL”: INVESTIGATING POOR HEALTH IN VULNERABLE COMMUNITIES IN THE NIGER DELTA REGION OF NIGERIA

By

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ABSTRACT

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The Niger Delta region in Nigeria has been exploited for decades due to extensive oil and gas deposits that have led to devastating livelihood and health consequences. In addition to oil and gas industry impacts, floods are intensifying in Niger Delta communities that have annual flooding during the rainy season (April to October). In 2012, Nigeria experienced a severe flooding event that damaged infrastructure and livelihoods with virtually no studies completed about the health consequences. This dissertation research study aims to fill this scholarly gap by disentangling the emerging health concerns in Niger Delta oil communities with particular attention to women and children as they are sensitive indicators of population health. It utilizes a mixed-methods approach with the inclusion of Eco-Syndemics and African womanism theoretical perspectives. It was found that the Niger Delta has multiple pre-existing vulnerabilities that put the population at more risk during flooding events. Also, through an evaluation of airborne concentrations of chemicals released by gas flares and a retrospective, cross-sectional comparison, women and children in Uzere (oil community) have greater exposure levels to toxic chemicals released and more health concerns than similar women and children in Aviara (non-oil community), even though both communities are located in flood-prone areas in the Niger Delta. Overall, this dissertation research advances our understanding of the complexity of health hazards in communities close to oil and gas activities in the midst of more severe flooding. It also enriches scholarly and policy debates by providing an initial assessment of the link between climate variability and health in vulnerable communities.

This dissertation is dedicated to my late brother, Thierno.
Thank you for encouraging me to follow my dreams.

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CHAPTER 1

AN INTRODUCTION TO THE DISSERTATION STUDY

1.1. INTRODUCTION

The Niger Delta population in Nigeria has been marginalized for decades due to the oil and gas industry's presence leading to lower educational levels, high underemployment and unemployment, structural violence, and health hazards. A child born in the Niger Delta region of Nigeria today is twice as likely to die by the age of 5 years compared to children in other southern regions of Nigeria (Antai, 2011). It has long been observed that infant mortality rates in a country/region is a strong indicator of overall population health (Reidpath and Allotey, 2003). Lack of investment in health infrastructure, lower maternal education and income levels, and home births are regularly cited as the reasons for higher levels of infant and child morbidity and mortality rates in sub-Saharan Africa. However, some scholars are beginning to note that place of residence in sub-Saharan Africa is more of a driver of these higher rates than individual-level risk factors alone (Antai, 2011; Margai and Barry, 2011; Adedini et al., 2015; Grady et al., 2016; Bruederle and Hodler, 2017). These place effects may include the rural and urban divide, where infant mortality rates in rural areas are almost double those in urban areas (Adedini et al., 2015) and toxic industries and toxic wastes that are legally or illegally located and/or dumped in communities with lower educational and income levels that emit noxious pollution (Ana et al., 2009; Gobo et al., 2009; Margai and Barry, 2011; Bruederle and Hodler, 2017). These spatial inequalities have been known to lead to greater population health risks with women of reproductive age and children as the most vulnerable groups resulting in poorer overall health of women, poor birth outcomes and higher levels of infant morbidity and mortality.

Furthermore, in recent years, natural disasters have been on the rise and in some cases, have become more intense, potentially exacerbating health hazards in many communities in sub-Saharan African (Woodruff et al., 1990; Kondo et al., 2002; Ahern et al., 2005; Lignon, 2006; Baer and Singer, 2009; Clements and Casani, 2016). In particular, flooding disasters due to heavy rainfall and poorly planned infrastructural development in certain regions are leading to devastating impacts on the livelihood and health of populations. Some communities are at greater risk than others depending on the politics and economic and environmental characteristics of the region. This is especially a concern in the Niger Delta due to its multiple pre-existing vulnerabilities such as climate variability and recurring flooding (extensive disasters), the fragility of the deltaic ecosystems to oil and gas extractive activities, poverty and inequality and lack of flood protective infrastructure such as dikes and levees.

Therefore, when addressing population health and more specifically, maternal and infant health in the Niger Delta, examining and identifying the root causes of poor health linked to place should be as much of a priority as increasing education and income levels and improving health infrastructure of the population. Furthermore, a context-specific approach that considers African theoretical perspectives would ensure a better understanding of the root causes and solutions of poor health as many Niger Delta communities suffer from grave disparities due to the presence of the oil and gas industry close to their homes and the region's ecological fragility to flooding disasters.

1.2. OIL POLLUTANTS and HEALTH CONSEQUENCES

For decades, the Niger Delta region has been exploited for its extensive oil deposits and gas that account for 95.0 percent of the Nigerian government's export earnings, and 75.0 percent of the federal budgetary revenue (World Bank, 2013). The Niger Delta has been used as the "basket" of national economic prosperity, which has discouraged improvements in infrastructural development and has led to high levels of poverty, chronic conflict, livelihood consequences and adverse health outcomes. Niger Delta communities lack many of the basic amenities such as potable water, sanitation, electricity and infrastructure including functional hospitals, schools and roads (United Nations Development Program [UNDP], 2006; Oviasuyi and Uwadiae, 2010). These communities are also surrounded by toxic oil and gas production that disperse pollutants into the environment through oil spills and gas flares, increasing exposure to hazardous chemicals (Ana et al., 2009; Gobo et al., 2009). Oil spills occur following mechanical failure and theft (UNEP, 2011; Ordinioha and Brisbe, 2013) and can take months to years to recover (UNEP, 2011; Geogewill, 2012). The amount of oil spillage in the Niger Delta is catastrophic with recent studies showing approximately 13 million barrels (1.5 million tons) of oil spilled since 1958 (Ordinioha and Brisbe, 2013), which is equal to 50 times the Exxon-Valdez oil spill in the United States in 1989. Gas flaring is associated gas released during oil production, which is piped and then burned in an open flame into the environment as waste or unusable gas. As of 2015, there were approximately 174 gas flare sites in the Niger Delta (National Oceanic and Atmospheric Administration [NOAA] et al., 2016). The World Bank and the United Kingdom Department for International Development (2005) found that approximately 75.0 percent of gas that was produced in the Niger Delta was flared. This amount is equivalent to 40.0 percent of natural gas consumption in Africa (Dung et al., 2008). Gas flares in the region are a major contributor of greenhouse gases in sub-Saharan Africa and have accelerated atmospheric warming and contributed to more volatile weather patterns in the region (Ndubuisi et al., 2007; ERA, 2008; Dung et al., 2008; Ismail and Umukoro, 2012). Nigeria is ranked seventh globally as a major contributor of gas flare emissions around the world (7,658 million cubic meters (m^3) flared in 2015) (NOAA et al., 2016). These flares comprise various toxic chemicals such as particulate matter (PM_{10}, $PM_{2.5}$ and PM aerosols), sulfur dioxide, nitrogen dioxide, benz[a]pyrene, dioxin, benzene, toluene, styrene, xylenes, and ethyl-benzene (Oluwole et al., 1996; Argo, 2001; ERA, 2008; Gobo et al., 2009; Ismail and Umukoro, 2012), some of which are carcinogenic and teratogenic.

There are direct and indirect consequences of oil and gas pollutants on population health and exposure can occur through skin contact, ingestion and inhalation. Oil and gaseous chemical-byproducts exposure to the skin can lead to sore eyes, burns, abrasions, rashes and dermatitis. Oil and gaseous chemical-byproducts can also be ingested via drinking water and foods (UNDP, 2006; Ordinioha, 2011; UNEP, 2011; Nriagu et al., 2016). Only 49.2 percent of rural communities in Nigeria have access to an improved source of safe drinking water, such as piped water, protected wells, and/or bottled water (National Population Commission [NPC] and ICF Macro, 2014). Ordinioha (2011) found that in rural communities in the Niger Delta drinking water was discolored with high iron and manganese content, and a metallic taste, as well as high counts of *Escherichia coli* (E. *coli*) from fecal-contaminated wastes. Exposure to oil spills and gas flares have also been reported to stunt the growth and lower the nutritional content of staple food crops due to the bioaccumulation of trace metals, contributing to a 24.0 percent increase in the prevalence of malnutrition in the region (Ordinioha and Brisbe, 2013). Dung et al. (2008) found that near a gas flare in Eleme, Rivers state in the Niger Delta, that cassava crops were stunted and had lower nutritional content and pepper plants were stunted and thinned. Ordinioha and Brisbe (2013) also found high concentrations of lead (90.0 percent) and cadmium (94.3 percent) in pumpkin leaves. Fish is the primary source of protein among residents, and for some, it is their main livelihood activity (Oladimeji et al. 1987; UNDP, 2006; UNEP, 2011). Bioaccumulation of heavy metals in fish in many rural Niger Delta communities has also been documented (Oladimeji et al. 1987).

Anyakora et al. (2008) found a high accumulation of benz(a)pyrene in fish sampled in the Niger Delta, which is a known environmental carcinogen and genotoxin. The general contamination of water and food sources has also led to poor nutrition, diarrheal diseases and decreased immunity, which independently and cumulatively increase the risk of infectious and chronic diseases (Okonta, 2007; Nkowcha and Egejuru, 2008; Anyakora et al., 2008; Ana et al., 2009; Gobo et al., 2009; Igberase et al., 2009; Ordinioha, 2011; Georgewill, 2012; Ismail and Umukoro, 2012; Olawoyin et al., 2012; Ordinioha and Brisbe, 2013; Abbey et al., 2017).

Inhalation of toxic pollutants and chemicals from gas flares have also been shown to increase the rates of respiratory diseases in Niger Delta's oil-producing communities (UNDP, 2006; Nkwocha et al. 2008; Ana et al., 2009; Gobo et al., 2009; UNEP, 2011; Ismail and Umukoro, 2012). The most common respiratory disease in the region is asthma (Gobo et al., 2009; Ismail and Umukoro, 2012), which is a chronic inflammatory disease associated with airway hyper-responsiveness that leads to recurrent episodes of wheezing breathlessness, chest tightness, and coughing (Desalu, Onyedum, et al., 2011; Singer, 2013b). Chronic inflammatory disorders are linked to respiratory mucosa, causing asthma, rhinitis and skin rashes such as eczema (Hopkins, 1997). A study by Nkowcha and Egejuru (2008) found that exposure to nitrogen oxides, sulfur oxides, and PM in children increased their risk of sinusitis, bronchitis, colds and coughs with phlegm. Overall, oil spills and gas flares have detrimental livelihood and health impacts on oil-producing Niger Delta communities. These livelihood and health consequences have been exacerbated by the environmental characteristics of the region, including annual flooding events.

1.3. HEAVY RAINFALL and FLOODING

In recent years, flooding has intensified in the region due to heavy rainfall and poorly planned infrastructural development increasing the vulnerability of the Niger Delta (Federal

Government of Nigeria et al. 2013; Agada and Nirupama 2015; Amangabara and Obenade 2015). Severe flooding in 2012 across coastal and riverine communities in Nigeria and in particular, in the Niger Delta, destroyed many homes and had significant impacts on local economies as many communities engage in climate-sensitive (rain-fed) agriculture. Oil wells and other oil and gas sector infrastructures in certain Niger Delta states were submerged and inoperable (Federal Government of Nigeria et al., 2013). However, it is unknown whether natural-technological (NaTech) events, which are natural hazards such as flooding that damage industrial facilities prompting the release of hazardous substances, have occurred as the oil and gas industry is unwilling to release this information to the public (Federal Government of Nigeria et al., 2013). Previous research in the United States and Europe have shown that flooding in regions with industrial facilities have sometimes led to toxic chemical releases that impact the environment and the health of populations living in close proximity to these facilities (Arellano et al., 2003; Young et al., 2004; Ruckart et al., 2008; Cruz and Krausmann, 2009; Sengul et al., 2012; Cruz and Krausmann, 2013). Additionally, the Niger Delta is not only burdened with potential hazardous releases during a flooding event, but this region is also known to have chronic oil spillage and gas flaring, and therefore, when flooding occurs it may increase the concentrations of the chemicals in the environment leading to increased health risks (Epstein, 2000; Osuji and Onoake, 2004; Appel, 2005; Dung et al., 2008; Cruz and Krausmann, 2013; Nigerian Ministry of the Environment, 2014; United Nations International Strategy for Disaster Reduction [UNISDR], 2018). Thus, the 2012 flood could have heightened an already hazardous situation. The combination of all these factors—flooding, oil pollution, poverty and conflict that results from displacement and loss of traditional livelihoods—keeps the Niger Delta in a loop of chronic stress, which directly impacts population health and could potentially lead to Syndemics. The Syndemics theoretical approach stems from the political ecology of health perspective and refers to the array of infectious and chronic diseases that emerge due to multi-factorial causes in marginalized communities without adequate health care (Singer and Clair, 2003; Baer and Singer, 2009; Singer, 2013a; Mendenhall et al., 2015) and climate variability or other human-induced environmental consequences, the latter of which is known as Eco-syndemics (Baer and Singer, 2009; Singer, 2013b). It is, therefore, imperative to determine the root causes of overall population health with a focus on maternal and infant health by assessing the health implications of social, economic and environmental agents and stresses associated with the extractive industry's activities and flooding in the Niger Delta.

1.4. PURPOSE OF THE STUDY

The purpose of this dissertation research is to assess the emerging health concerns in the Niger Delta with particular attention to women and children as their health and well-being is a sensitive indicator of the overall health of a community. It is hypothesized that women and children in oil-producing Niger Delta communities are more vulnerable and susceptible to poor health due to their heightened exposures to pollutants released by the oil and gas industry (Udonwa et al., 2004; Ana et al., 2009; Gobo et al., 2009; Antai, 2011; Bruederle and Hodler, 2017) and flooding hazards. The Eco-Syndemic theoretical approach will be utilized as it acknowledges the complexity of multiple factors underlying the health profile of a community (Singer and Clair, 2003; Baer and Singer, 2009; Singer, 2013b; Jackson and Neely, 2014). These factors include, the causes underlying an array of infectious and chronic diseases triggered (epidemic) and sustained (endemic) in the community due to hazardous oil and gas chemicals, climate variability, marginalization, lack of education, unemployment, economic deprivation and structural violence. The acute and chronic effects of these cumulative exposures in women and children can therefore, have long-term health consequences for themselves and their communities.

The goal of this study is to improve our understanding of population health implications of the oil and gas industry and natural disasters (flooding) in Niger Delta communities. The objectives of this study are:

1) To further understand natural disasters and NaTech events around the world and how they apply in the Niger Delta.

2) To determine whether the inclusion of African theoretical perspectives such as Africana womanism in political ecology of health will help to provide a better understanding of women's roles, the environment and health in the Niger Delta.

3) To determine whether women and children in an oil producing community have higher exposure levels and worse health concerns and outcomes compared to similar women and children in a non-oil producing community when both communities are located in flood-prone areas in the Niger Delta.

This dissertation is formatted to include this Introduction (Chapter 1) followed by three chapters that highlight the objectives of this study. Chapter 2 focuses on the human-environment challenges of flooding and the increased vulnerability of oil-producing communities in the Niger Delta to NaTech events. This chapter will describe how the Niger Delta is unique due to its pre-existing vulnerabilities, including the fragility of deltaic ecosystems to oil extraction, recurring floods, climate variability, poorly planned infrastructural development and poverty. Chapter 3 will focus on African theoretical perspectives that will provide a fuller picture of women's roles, the environment and health concerns in sub-Saharan Africa. It addresses the reasons why certain Westernized theoretical perspectives may not always be inclusive of local traditions and customs in research studies conducted in sub-Saharan Africa. This chapter, therefore, frames the Africana womanist theoretical perspective within the context of the impact of Westernized ideologies in Africana communities and how useful Africana womanism can be if used as an extension of (African and Black) feminist political ecology (of health) to develop context-specific research questions and analysis of results in communities in sub-Saharan Africa. Chapter 4 uses the knowledge from chapters two and three to assess whether women and children in an oil producing community (Uzere) are exposed to more toxic pollutants and have worse health concerns (eco-syndemics) compared to women and children in a non-oil producing community (Aviara), both of which are located in flood-prone areas in Delta State, Nigeria. It includes an environmental assessment of the airborne concentrations of five chemicals emitted from a gas flare in Uzere that are hazardous to health. It is followed with the results from group surveys of 208 women in Uzere and Aviara implemented in November 2016 to determine the various self-reported symptoms, health conditions and diseases that women and children experience during the flood-prone season. Finally, Chapter 5 summarizes the discussions in the former chapters and will give an outlook on future directions to further improve the health of people and communities in the Niger Delta region of Nigeria.

CHAPTER 2

NATURAL DISASTERS IN OIL-PRODUCING COMMUNITIES IN THE NIGER DELTA

ABSTRACT

Despite increasing environmental and population vulnerability in the world due to climate variability and poorly planned infrastructural development, there is limited knowledge on the health implications of the release of hazardous substances when industrial facilities are damaged by natural disasters in sub-Saharan Africa, also known as natural-technological (NaTech) events. In 2012, Nigeria experienced severe flooding due to increased rainfall and the release of water from the Lagdo Dam in neighboring Cameroon. This intensive flooding disaster led to the displacement of thousands of people and the destruction of homes and livelihoods in Nigerian riverine and coastal communities. Oil-producing communities in the Niger Delta were particularly affected due to multiple pre-existing vulnerabilities such as climate variability and recurring flooding (extensive disasters), the fragility of deltaic ecosystems from oil and gas extractive activities, poverty and inequality and lack of flood protective infrastructures. However, due to limited studies, it is unknown whether the Niger Delta region is more vulnerable to natural disasters. This chapter fills this gap by describing intensive and extensive disasters and NaTech events around the world and how the multiple pre-existing vulnerabilities of the Niger Delta exacerbate livelihood and health consequences during natural disasters. It also identifies the loopholes in various international, regional and national policies regarding disaster risk reduction and industrial facilities. It concludes with future research needs to address the emerging risks of intensive and extensive disasters in oil-producing communities in the Niger Delta.

2.1. INTRODUCTION

Natural disasters have been on the rise in recent years and have increased population vulnerability around the world, particularly in low-income regions (Intergovernmental Panel on Climate Change [IPCC], 2001, 2007, 2013; United Nations International Strategy for Disaster Reduction [UNISDR], 2015; International Union for Conservation of Nature [IUCN], 2016; Gordy, 2016). Natural disasters are commonly associated with extreme weather events –e.g., earthquakes, floods, tropical cyclones and hurricanes, also known as intensive disasters (Dodman et al., 2009; Hamdan, 2015; UNISDR, 2015; Gordy, 2016; UNISDR, 2018). Intensive disasters are severe natural disasters with high levels of population mortality and in the presence of industrial facilities, spillover exposures may be even more damaging to the environment and health of populations (Arellano et al., 2003; Young et al., 2004; Ruckart et al., 2008; Cruz and Krausmann, 2009; Sengul et al., 2012; Cruz and Krausmann, 2013). This phenomenon is known as natural–technological (NaTech) events because natural hazards trigger technological disasters by releasing hazardous substances from damaged industrial facilities. Although there has been substantial research on the risks associated with intensive disasters and NaTech events in Europe and the United States (Arellano et al., 2003; IPCC 2007; Ruckart et al., 2007; Krausmann and Mushtaq, 2008; Cruz and Krausmann, 2009; Sengul et al., 2012; Cruz and Krausmann, 2013), little research has been conducted to document the extent and severity of NaTech events on the African continent where extractive industries are common and the impacts of natural disasters are generally associated with extensive disaster risks (Cruz and Krausmann, 2013; Gordy, 2016; UNISDR, 2018).

Extensive disasters are highly-localized, recurring natural hazards with lower levels of mortality often exacerbated by urbanization, poverty and environmental degradation (Dodman et al., 2009; Hamdan, 2015; UNISDR, 2015; Gordy, 2016; UNISDR, 2018). Some scholars have found that the recurring nature of these natural hazards may potentially lead to intensive disasters overtime due to their cumulative effects and therefore, should be examined jointly (Gordy, 2016; UNISDR, 2018). Although the African continent has a low percentage of intensive disasters, it has some of the highest percentages of affected and displaced people and premature mortality compared to other continents experiencing similar events (IPCC, 2007; Guha-Sapir and Hoyois, 2013; IUCN, 2016). The most common natural disaster on the African continent is flooding. In 2012, Nigeria experienced one of the most severe flooding events in their modern history with 7 million people affected and 363 deaths (Guha-Sapir and Hoyois, 2013). Two years later, it was estimated that 70.0 percent of Nigerians lived in areas at risk of riverine flooding in 25-, 50-, and 100-year flood zones (Federal Government of Nigeria et al., 2013; Agada and Nirupama, 2015) representing a four, two, and one percent chance, respectively, of a flood event occurring in any given year. Some of the important reasons for the vast number of people affected by flooding in Nigeria are poorly planned infrastructural development, dam construction in neighboring countries, lack of early warning systems, and inefficiency in disaster response preparedness (Federal Government of Nigeria et al., 2013; Guha-Sapir and Hoyois, 2013; Amangabara and Obenade, 2015; Enete et al., 2015; Musa et al., 2016).

However, the Niger Delta, located in southern Nigeria is potentially more vulnerable to severe floods due to increased rainfall and annual flooding events, its fragile deltaic environment as a result of oil and gas extraction, poverty and the lack of flood protective infrastructure such as dikes and levees (Ogri, 2001; Cruz and Krausmann, 2013; UNISDR, 2018). While post-assessments of the 2012 flooding event were conducted to determine the extent and severity of damage in Nigeria, there was insufficient reporting on the human-environmental impacts in communities close to oil and gas facilities, particularly whether they may have experienced one or more NaTech events (Federal Government of Nigeria et al., 2013; Amangabara and Obenade, 2015). It is also unknown whether the region's pre-existing vulnerabilities may have exacerbated the severity of the 2012 flooding event.

This chapter describes the human-environment challenges of flooding in Niger Delta communities that are located close to oil and gas facilities. It begins with a description of intensive and extensive disasters and risks with specific attention to flooding and NaTech events around the world. It is followed with a description of the Niger Delta's multiple pre-existing vulnerabilities to natural disasters. The chapter concludes by examining the international, regional and national policies on disaster risk reduction focused on the impacts of industrial facilities. It also discusses future research needs to determine the various risks associated with flooding in communities with pre-existing vulnerabilities.

2.2. BACKGROUND ON INTENSIVE and EXTENSIVE DISASTERS and RISKS

Natural disasters are overwhelmingly associated with extreme weather events, also known as intensive disasters, and result in high levels of mortality. However, extensive disasters may be even more problematic due to their recurring nature and association with higher levels of displacement and morbidity (UNISDR, 2015). Although there has been less of a focus on the risks of extensive disasters on a global scale, there is a need to further understand extensive disasters because solutions that are developed locally may potentially increase intensive disaster risks (Gordy, 2016; UNISDR, 2018). Therefore, this section discusses why intensive and extensive disasters cannot be examined separately if sustainable and effective solutions are to be developed to reduce their risk in communities.

Intensive disasters are intense hazard events that can lead to high levels of mortality and asset loss (Dodman et al., 2009; Hamdan, 2015; UNISDR, 2015). Natural disasters are classified as intensive when 30 or more deaths and 600 or more homes are destroyed (UNISDR, 2015). It is important to note that in many regions of the world, an intensive disaster can be catastrophic not only because of a region's exposure to a natural hazard, but also the vulnerabilities and the underlying risk factors in the region (UNISDR, 2015; Gordy, 2016). These underlying vulnerabilities are especially problematic for extensive disasters, which are small, but frequent disasters associated with weather-related events (Dodman et al., 2009; Hamdan, 2015; UNISDR, 2015; Gordy, 2016).

Extensive disasters are normally observed in low- and middle-income countries because, in most cases, high-income countries have made the necessary investments to reduce extensive risks and have higher levels of social protection services, such as emergency services and health coverage in the aftermath of a natural disaster (Gordy, 2016). Some of the risk factors that increase the vulnerability of populations during extensive disasters in low- and middle-income countries include poorly planned infrastructural development, environmental degradation, weak governance, and poverty and inequality (Dodman et al., 2009; Hamdan, 2015; UNISDR, 2015; Gordy, 2016). Intensive and extensive disasters create a feedback loop into poverty as many poor communities are less likely to be able to recoup the assets that were lost or damaged (UNISDR, 2015; Gordy, 2016). Furthermore, due to the recurring nature of extensive disasters and its lower levels of deaths in the short-term, local economic losses and the impacts on the population's livelihoods and health are less likely to be assessed and reported (UNISDR, 2015). For instance, extensive disasters such as droughts or recurring floods have been found to increase food insecurity indirectly leading to higher death rates due to malnutrition and starvation (Gordy, 2016). However, in some countries, these higher death rates are not considered a result of extensive disasters but rather the low standard of living prior to the disaster. Therefore, Gordy (2016) hypothesizes that deaths from extensive disasters are potentially undercounted.

Infrastructural development to account for urbanization and to protect against extensive disasters have also been found to increase the impacts of intensive disasters. For instance, Gordy (2016) explains that urbanization and flood prevention measures were put in place in Dhaka, Bangladesh, which is prone to multiple natural hazards. However, these measures also included draining the wetland, which increased the impacts of earthquakes in the region since sand and silt can liquefy during an earthquake leading to the collapse or serious damage of buildings and infrastructure (Gordy, 2016). In Port Harcourt, Nigeria, one of the major oil cities in the Niger Delta, a 10-hour rainfall in July 2006 displaced over 10,000 residents due to flooding that was aggravated by the construction of the Port Harcourt-Patani-Warri highway that acts as a barrier to floodwaters (Dodman et al., 2009). These case studies highlight the need to have a broader lens to implement protective measures for natural disasters in development initiatives –i.e., they need to be addressed conjointly.

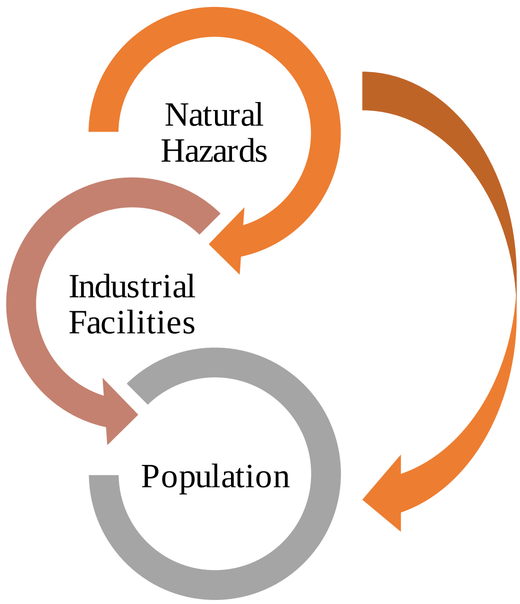
Major economic assets such as oil and gas industry facilities have increasingly been located in hazard-prone areas (Cruz and Krausmann, 2009; Cruz and Krausmann, 2013; UNISDR, 2015; Gordy, 2016). Intensive disasters tend to cause severe damage to the infrastructure of these industrial facilities leading to major economic losses. However, less attention has been given to the hazardous chemicals that are potentially released during natural disasters that may create NaTech events. The next section will further describe NaTech events with particular attention to floods and hurricanes across the globe.

2.3. NATECH EVENTS

Natural hazards such as hurricanes, floods and earthquakes, are not unavoidable, but the severity of their impacts can be diminished. This is even more critical in regions of the world where natural disasters damage industrial facilities due to the heightened risk of exposure to hazardous substances (Arellano et al., 2003; Young et al., 2004; Ruckart et al., 2008; Cruz and Krausmann, 2009; Sengul et al., 2012). Between 1990 and 2008, natural hazards were the cause of 16,600 hazardous releases that were reported to the United States Coast Guard National Response Center; 26.0 percent of which were rain-induced releases (Sengul et al., 2012). This section will focus on natural hazards such as floods and hurricanes that have triggered multiple chemical releases and accidents leading to technological disasters and health implications.

Natural disasters in regions where industrial facilities are present, also known as NaTech events, have different outcomes on the health and security of the population due to the potential releases of toxic substances when their facilities are damaged (Arellano et al., 2003; Cruz et al., 2006; Cruz and Krausmann, 2009). This is what Arellano et al. (2003) consider a "domino effect," where natural hazards do not only directly impact the population, but the damage on industrial facilities is so great that releases of hazardous substances into the environment are eminent, compounding population vulnerability and potential risks (Figure 2-1) (Arellano et al., 2003). In essence, populations close to industrial facilities during natural disasters are at increased risk due to the potential widespread contamination of the air, soil and water (Krausmann and Mushtaq, 2008; Cruz and Krausmann, 2009). These NaTech events have led to economic loss, health consequences and in some cases, loss of life.

Figure 2-1: Domino Effect of NaTech Events.



Sources: Graphic adapted from Degg's Model of Earthquake Disasters, 1992 and the description of the domino effect in NaTech events in Arellano et al. 2003.

Natural disasters have been known to rupture oil and gas pipelines and other infrastructures that house toxic substances (Cruz et al., 2006). The oil and gas industry have serious challenges due to the large economic impact that their facilities endure when there is a natural disaster and the environmental and health consequences of the release and spillage of hazardous substances (Cruz and Krausmann, 2013). Furthermore, oil and gas facilities tend to be located in low-lying areas on-shore and off-shore, which exposes them to coastal flooding, storm surges, rising sea levels, ground subsidence and erosion (Paskal, 2009; Cruz and Krausmann, 2013). If rainfall and flooding are the norm in these areas, climate variability and extreme rainfall events may exacerbate local conditions leading to more difficulties (Cruz and Krausmann, 2013).

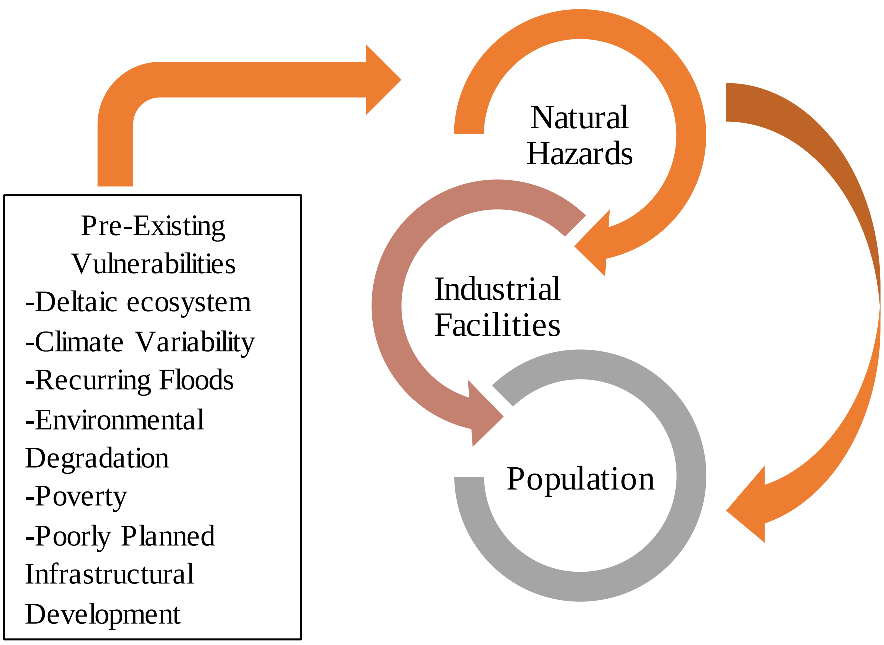
Flooding is one of the main causes of NaTech events during hurricanes and other intensive disasters (Arellano et al., 2003; Cruz et al., 2006). However, there are limited studies on the impacts of flooding-induced NaTech events (Krausmann and Mushtaq, 2008) and limited models that estimate equipment damage from severe flooding (Landucci et al., 2012; Landucci et al., 2014). Floods are often difficult to contain especially in instances of flash floods or floods that inundate areas for longer periods of time (Krausmann and Mushtaq, 2008). The severity of a flooding event is influenced by two main parameters: water height and water velocity (Young et al., 2004; Krausmann and Mushtaq, 2008; Landucci et al., 2012; Landucci et al., 2014). There are three main levels of severity: 1) low-flood, where the flood is slow rising and lasts for less than a day, which would allow anti-flood measures to be taken, 2) intermediate-flood, where the water height is less than 1.5 meters, but the flood has lasted for a few days, and slight damage to buildings and infrastructure would be dangerous for people to move, and 3) high-flood, where the water height exceeds 1.5 meters, flood lasts for several days or even weeks, buildings and infrastructure have suffered extensive damage, and the risk of drowning and death are high (Krausmann and Mushtaq, 2008).

In 2005, the high winds and flooding from Hurricanes Katrina and Rita caused vast damage to the oil and gas industry in the southern United States leading to the release of hazardous substances, particularly oil spills, onshore and offshore (Cruz and Krausmann, 2009; Burkett, 2011). The oil that was spilled (30.2 million liters) due to these hurricanes came close to the Exxon Valdez oil spill in 1989 (41 million liters), which was considered one of the worst human-caused natural disasters (Cruz and Krausmann, 2009). Toxic air releases from industrial facilities in preparation for and in the aftermath of Hurricanes Katrina and Rita represented 91.4 percent of all releases (Ruckart et al., 2008). In addition, some of the industrial facilities had to release large amounts of chemicals such as nitrogen oxide and sulfur dioxide into the air to shut down their operations in preparation for the hurricanes and to start up once the hurricanes had passed (Ruckart et al., 2008). Other facilities inadvertently released hazardous substances due to the damage of their facilities and storage terminals (Cruz and Krausmann, 2009; Perrow, 2011). Clean up processes of oil spilled were also delayed due to laws that stopped companies from remediating private property without the owner's permission (Perrow, 2011). This increased the saturation of oil contaminants in the soil reducing its fertility and also increasing human health risks. Many people in surrounding areas reported suffering from nausea, dizziness and skin irritation in the short-term (Perrow, 2011). In the long-term, Rhodes et al. (2010) found that the prevalence of serious mental illnesses had doubled and post-traumatic stress syndrome was evident in half of those surveyed in the aftermath of Hurricane Katrina.

Other studies have found that cancer, respiratory illnesses, and emotional stress increase after flooding around industrial facilities (Young et al., 2004). Schmidt (2000) found that stress and respiratory problems were increasingly reported after Hurricane Floyd in 1999 breached waste lagoons in North Carolina. Leukemia and lymphoma rates increased by 35.0 percent in areas affected by flooding from Tropical Storm Agnes compared to non-flooded areas in New York (Janerich et al., 1981). These outcomes were mostly found to be a result of emotional stress and exposure to environmental contaminants during and in the aftermath of the flood. More research will have to be conducted to understand the contribution of flooding to health hazards close to industrial facilities.

This is even more critical in regions of the world, such as sub-Saharan Africa, where there are not as many intensive disasters, but there are extractive industries and the impacts of extensive disasters may be devastating due to pre-existing vulnerabilities. Communities close to industrial facilities in sub-Saharan Africa, similarly to the United States and Europe, may be more vulnerable due to the potential releases of toxic substances. However, due to multiple pre-existing vulnerabilities in many sub-Saharan African countries, the domino effect is slightly altered (Figure 2-2). For instance, in the Niger Delta in Nigeria, a coastal, oil-producing region, multiple pre-existing vulnerabilities include climate variability and recurring flooding (extensive disasters), the fragility of the deltaic ecosystems to oil and gas extractive activities, poverty and inequality and lack of flood protective infrastructure. These pre-existing vulnerabilities may lead to intensive disasters, which increase the disaster risks on populations. The next section will focus on the Niger Delta, which has dealt with decades of environmental degradation due to oil and gas industry activities, poverty and recurring flooding. In recent years, however, this region has experienced more intense flooding due to climate variability and dam development in neighboring countries.

Figure 2-2: Domino Effect of NaTech Events and Pre-Existing Vulnerabilities in the Niger Delta, Nigeria.



Sources: Graphic adapted from Degg's Model of Earthquake Disasters, 1992, the description of the domino effect in NaTech events in Arellano et al. 2003, and pre- and post-disaster vulnerabilities to extreme weather-related disasters in urban areas in Dodman et al. 2009.

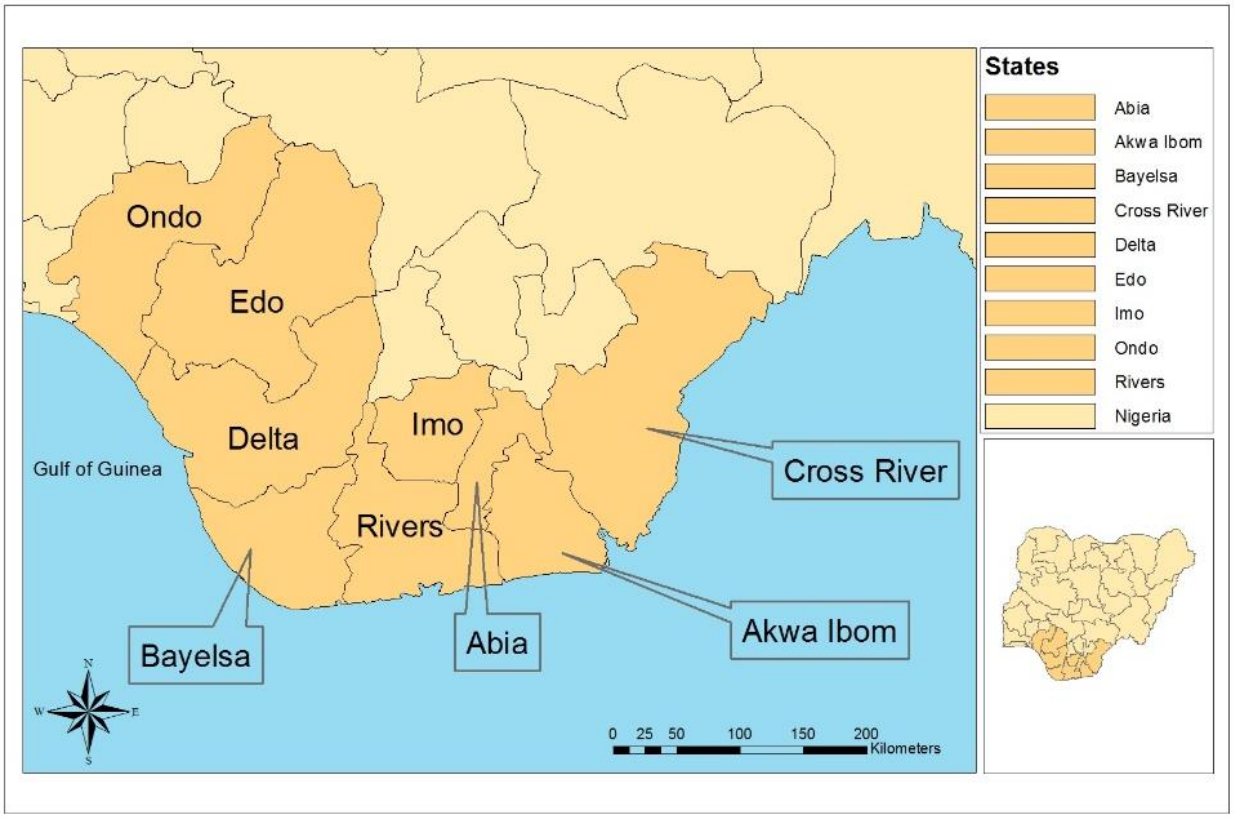
2.4. PRE-EXISTING VULNERABILITIES IN THE NIGER DELTA

A number of countries in sub-Saharan Africa remain vulnerable to natural disasters due to poor economic, political, social and environmental decisions (Wisner et al., 2004). This is even more evident in regions that are exploited for their natural resources at the detriment of local livelihoods and health of populations. The Niger Delta is one of those regions that has been exploited for decades for oil and gas resources without considering environmental impacts and proper compensation to local communities (Watts, 1999, 2005; Adeola, 2001). The discovery of oil in 1956 had initially brought a sense of hope due to the decline in palm oil sales in the region (Ukiwo, 2007). However, as the Nigerian Government became more involved in the international economic structures, they regulated the oil industry according to the rules of the Organization of the Petroleum Exporting Countries (OPEC), which included the nationalization of natural resources leading to a reduction in the revenues directed to the communities in exchange for propelling the national economy. The nationalization of natural resources led to much protest and conflict in the region as the communities were finding themselves increasingly unable to improve their standard of living and were forced to engage in subsistence agriculture and fishing (Ikelegbe, 2001; Ukiwo, 2007). Today, the Niger Delta is still vulnerable and the serious ecological impacts of oil extraction, poverty and inequality, recurring flooding and the increasing intensity of flooding in the region may increase the region's vulnerability.

2.4.1. The Fragility of the Delta to Oil Extraction and Poverty

The Niger Delta (Figure 2-3) in southern Nigeria was created following the breakup of the Gondwana during the Mesozoic era, which separated South America from the African continent, following a series of rifts in a triple junction in the present-day Gulf of Guinea (Doust and Omatsola, 1989; Tuttle et al., 1999; Reijers, 2011). It is one of the largest deltas in the world covering 75,000 square kilometers (km^2) with its source in the Guinean Highlands. The Niger River flows through Guinea, Mali, Niger, Benin forming a deltaic plain in Nigeria with its receiving basin in the Gulf of Guinea. The Niger Delta is rich in both oil and gas. In 1989, it was estimated that this region had over 26 billion barrels (bbl) of oil and an underestimated gas resource base (Doust and Omatsola, 1989). As of 1999, 34.5 bbl of recoverable oil and 93.6 trillion cubic feet of recoverable gas had been discovered (Tuttle et al., 1999). The extensive oil and gas deposits account for 95.0 percent of the Nigerian government's export earnings, and 75.0 percent of the federal budget revenue (World Bank, 2013a).

Figure 2-3: Map of Niger Delta region of Nigeria.



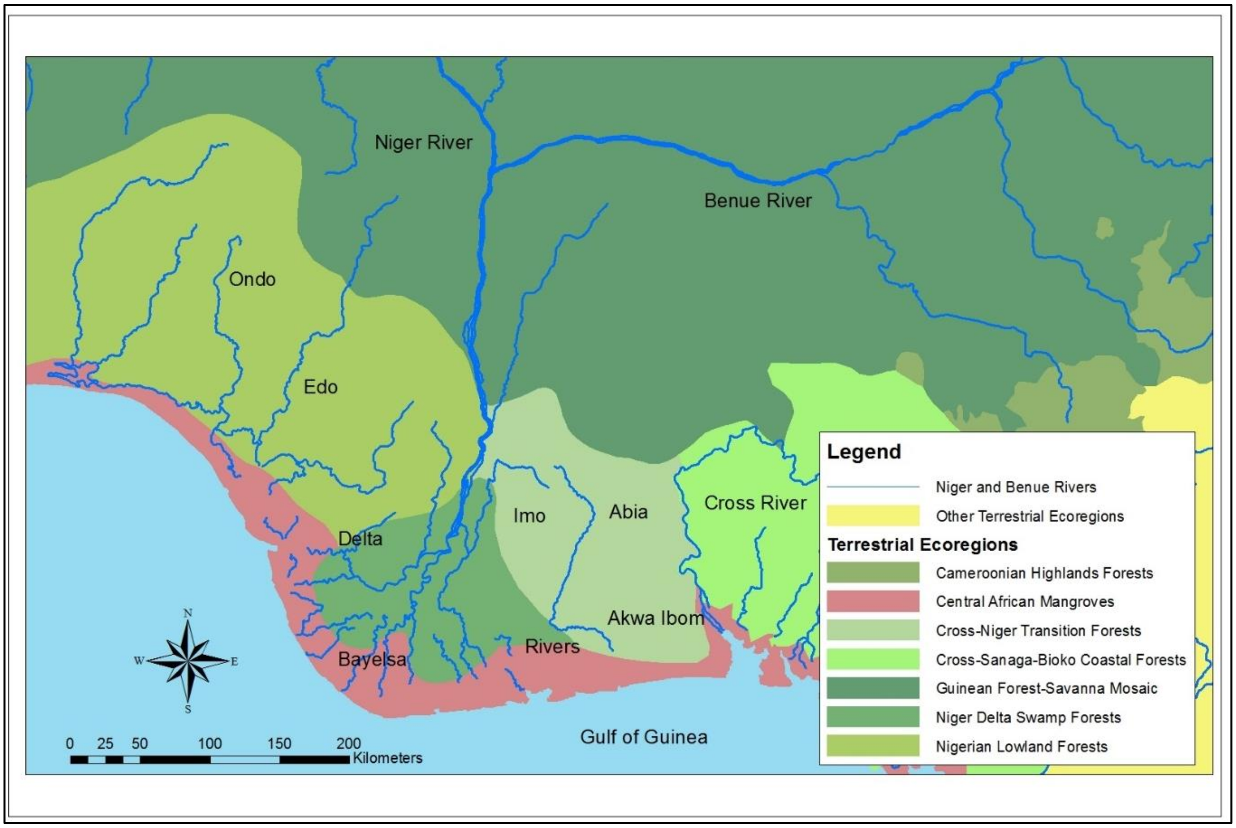
Source: United Nations Office for the Coordination of Humanitarian Affairs in Nigeria (UNOCHA-Nigeria), 2015; Map created by Fatoumata B. Barry, 2017.

The Niger Delta has abundant natural resources because over long periods of time, this delta trapped organic and inorganic sediments, including clays, sandstones, and siltstone which transformed the landscape into unique structural forms (Doust and Omatsola, 1989). The biodiversity of the landscape allowed natural resources such as hydrocarbons, the major components of oil and gas found in reservoirs of shale-rich sediments, to thrive. Sediments found in most deltas today, including the Niger Delta were deposited in the early Tertiary period (Paleocene Epoch – almost 65.5 million years ago) (Tuttle et al., 1999). The Niger Delta has sediments that formed into marine shales. This delta consists of shales, clays, and silts (Akata Formation) from the early Eocene (55.8–33.9 million years ago) at its base; paralic clastics consisting of sands, silts, and clays—the hydrocarbon-prospective sequence (Agbada Formation) from the Eocene and Miocene (33.8–5.3 million years ago)—and continental sands that are entirely non-marine sands (Benin Formation) from the Pliocene and Pleistocene (5.2 million– 10 thousand years ago) (Ko and Day, 2004; Reijers, 2011). Almost all hydrocarbon accumulations in the Niger Delta have been found in the Agbada Formation and the upper part of the Akata Formation, mostly trapped in rollover anticlines (Short and Stauble, 1967; Coleman and Wright, 1975; Tuttle et al., 1999; Ko and Day, 2004), which occur on the basin side of a growth fault. When the growth fault moves, a gap forms that allows sediments to roll over and fall into the gap (Hyne, 2012).

Although the Niger Delta has abundant oil and gas resources, the resource curse, which is when countries that are rich in natural resources have worse development outcomes, has led to detrimental effects on the environment (Ogri, 2001; Ko and Day, 2004) and forced many communities into poverty and lower standards of living (Watts, 1999; Adeola, 2001). Exploration and extraction of oil reserves are two of the most destructive activities in this fragile delta environment as they involve the clearing of trees, installation of drilling equipment and pipelines, and development of access roads (Ogri, 2001; Ko and Day, 2004). These activities have serious ecological impacts, with disruption of the soil structure and composition, vegetation, flora and fauna, and increases in deforestation and soil erosion rates. Furthermore, oil exploration and extraction often contaminate ground surfaces and groundwater with chemicals released, including benzene, xylene, and other toxic chemicals harmful to the environment and human health (Ana et al., 2009). The deltaic plains of the Niger Delta are generally composed of marshes and mangrove swamps (wetland) (Figure 2-4.), which are highly susceptible to ecological degradation (Ko and

Day, 2004). Any disruption to the natural hydrologic flows can restrict the nutrients and sediments that are needed for wetland vegetation to thrive (Ko and Day, 2004).

Figure 2-4: Terrestrial Ecoregions of the Niger Delta region of Nigeria.



Source: Harvard University Center for Geographic Analysis, 2011; Map created by Fatoumata B. Barry, 2018.

Other environmental consequences associated with oil extraction is that it can cause depressurization that enhances the subsidence of soils (Ko and Day, 2004; Syvitski et al., 2009). Pipelines that transport oil and gas disrupt the natural hydrological channels and patterns and are prone to spills or accidental releases (Ko and Day, 2004). Although the quantity of oil spilled in the region is controversial, recent studies have found that approximately 13 million barrels (1.5 million tons) of oil has spilled since 1958 (Ordinioha and Brisbe, 2013). These spills increase water turbidity, introduce toxicity to the environment and degrade vegetation and habitats (Ko and Day, 2004). These spills also disrupt the plant-water relationship impacting plant metabolism and reduces the oxygen exchange between the soil and atmosphere (Ko and Day, 2004). Oil spillage has also been known to decrease the value of estuarine zones that are nursing grounds for fish and shrimp, which many communities are reliant upon for their nutritional needs, income and survival (Ko and Day, 2004).

Soil erosion, particularly gully erosion, is another major impact from oil extraction and production in the Niger Delta. Gully erosion reduces soil fertility through soil removal by surface water runoff (Federal Government of Nigeria et al., 2013; IUCN, 2016). It is estimated that there are 3,000 gullies, which measure up to 10.0 km in length along the southern coast of Nigeria (Federal Government of Nigeria et al., 2013; Amangabara and Obenade, 2015). There are various reasons that gully erosion is increasing in the region, however, unsustainable land-use practices, such as oil extraction, is the primary factor as it removes protective vegetation cover and disturbs fragile ecosystems including soils (Federal Government of Nigeria et al., 2013; Amangabara and Obenade, 2015; IUCN, 2016). Oil extraction has had many consequences on the environment in the Niger Delta, particularly on the livelihoods and health of populations in the region.

Once a rich farming and fishing area, the residents of the Niger Delta are largely reduced to subsistence farming and fishing and poverty-level incomes (United Nations Development Program [UNDP], 2006; Ogunlela and Muhktar, 2009), small service provision and trading (UNDP, 2006), and contractual work or payoffs from the oil industry (UNDP, 2006). Approximately 60.0 percent of the Niger Delta population depends on the natural environment such as farming and fishing for their livelihoods (World Bank, 2003). Few residents work in the oil industry as most oil workers come from the foreign companies operating in the region (UNDP, 2006). Housing is relatively poor, underemployment, unemployment and poverty are high in the Niger Delta, with a poverty incidence of 55.0 percent, which is the proportion of the population with per capita income less than the per capita poverty threshold (World Bank, 2008). A World Bank (2003) study found that the Niger Delta's per capita income was 360 USD, while Nigeria's per capita was 513 USD. This disparity is mostly due to an increasing population in the region with less access to employment opportunities, particularly youth unemployment which is around 40.0 percent (World Bank, 2008). In 2006, the Niger Delta's population was 31.2 million and it is projected to grow to 45.7 million by 2020 (World Bank, 2008). The lack of stable employment opportunities has contributed to political instability and conflict in the region for decades (Watts, 1999, 2005; Ibeanu, 2000; Ikelegbe, 2001; Adeola, 2001; World Bank, 2003; World Bank, 2008).

Moreover, residents are chronically exposed (through inhalation, ingestion, and dermal and perinatal contact) to oil and gas-byproduct pollution, increasing population susceptibility to diseases and reduced overall health and wellbeing (UNDP, 2006; Ana et al., 2009). Poor and inaccessible health care services exacerbate health issues and increase infant, child and premature mortality. The government and oil companies view activists advocating for improved quality of social services and access to resources to meet basic daily needs as problem-seekers and in the past, protests were often dealt with violently (Ikelegbe, 2001). Therefore, most of the local residents lack a voice to advocate against oil-industry induced pollution and environmental degradation, and for sustainable livelihoods, health and social wellbeing. Thus, environmental injustice is a profound challenge in the Niger Delta. The oil industry has degraded the environment, brought false hope for local economic prosperity and increased the vulnerability of the Niger Delta. The increasing threat of severe flooding due to climate variability and lack of flood protective infrastructure will potentially make the Niger Delta even more vulnerable (Federal Government of Nigeria et al., 2013; Amangabara and Obenade, 2015).

2.4.2. Recurring Flooding and Climate Variability

In the past decade, 85.0 percent of deltas worldwide experienced severe flooding not only due to sea-level rise, but also the increasing frequency and intensity of natural hazards such as hurricanes and cyclones (Goldenberg et al., 2001; Holland and Webster, 2007; IPCC, 2007; Syvitski et al., 2009). The Niger Delta is experiencing more flooding due to climate variability and poorly planned infrastructural development in recent years (Umoh, 2002; Odjugo, 2005). The Niger Delta's physical attributes and network of estuaries, rivers, creeks, and streams makes it susceptible to flooding on an annual basis during the rainy season (April to October). This region is mostly impacted by riverine flooding, which normally occurs when there is increased rainfall over an extended period of time, causing a river to overflow after it exceeds its capacity (Clements and Casani, 2016). The Niger Delta receives over 90.0 percent of all water flowing through the Niger-Benue River systems (Amangabara and Obenade, 2015). The region's terrain is flat and there are homes and local economic activities along the river systems that are highly vulnerable to flooding. According to Amangabara and Obenade (2015), the main Niger Delta states (Delta, Bayelsa and Rivers) have approximately 580 rivers prone to flooding that will likely impact 2,148 towns within 1.5 km of the rivers. Delta state has the highest risk of flooding in the Niger Delta because it has the largest number of rivers and communities located along or close to rivers (Amangabara and Obenade, 2015). However, over the past few years, there has been more severe flooding, destabilizing communities as traditional resilience mechanisms to deal with these dangerous floods have become inadequate (Federal Government of Nigeria et al., 2013; interviews with representatives of Uzere and Aviara [Delta state] and Ogboloma and Okolibiri [Bayelsa state], 2014; Akukwe and Ogbodo, 2015; Agada and Nirupama, 2015; Amangabara and Obenade, 2015).

One cause of the increased intensity of flooding in the region is climate variability. The climate of the Niger Delta is categorized as tropical monsoon according to the Köppen classifications (Climate-Data, 2018). Although studies have generally found that climate in west Africa is influenced by the Intertropical Discontinuity, which is a narrow zone where trade winds of the two hemispheres converge, the southern region of Nigeria is mostly influenced by sea surface temperatures from the Gulf of Guinea (Odekunle, 2010). This implies wetter conditions in the southern region of Nigeria (Odekunle, 2010) due to warmer sea surface temperatures (Vizy and Cook, 2001; Niang et al., 2014). Since the 1940s, there have been intermittent periods of wetter and drier years leading to less predictable climate patterns across Nigeria (Uyigue and Agho, 2007; Akinsanola and Ogunjobi, 2014). Although there has been reduced rainfall in Nigeria overall (Oladipo 1995; Akinro et al. 2008), the southern coastal regions are experiencing similar levels of rainfall from wetter periods dating back to the 1960s (Adefolalu, 1986; Odjugo, 2005; Akinsanola and Ogunjobi, 2014) and an increase of approximately one month in the rainy season, extending the length of the rainy season in the region (Odekunle 2007).

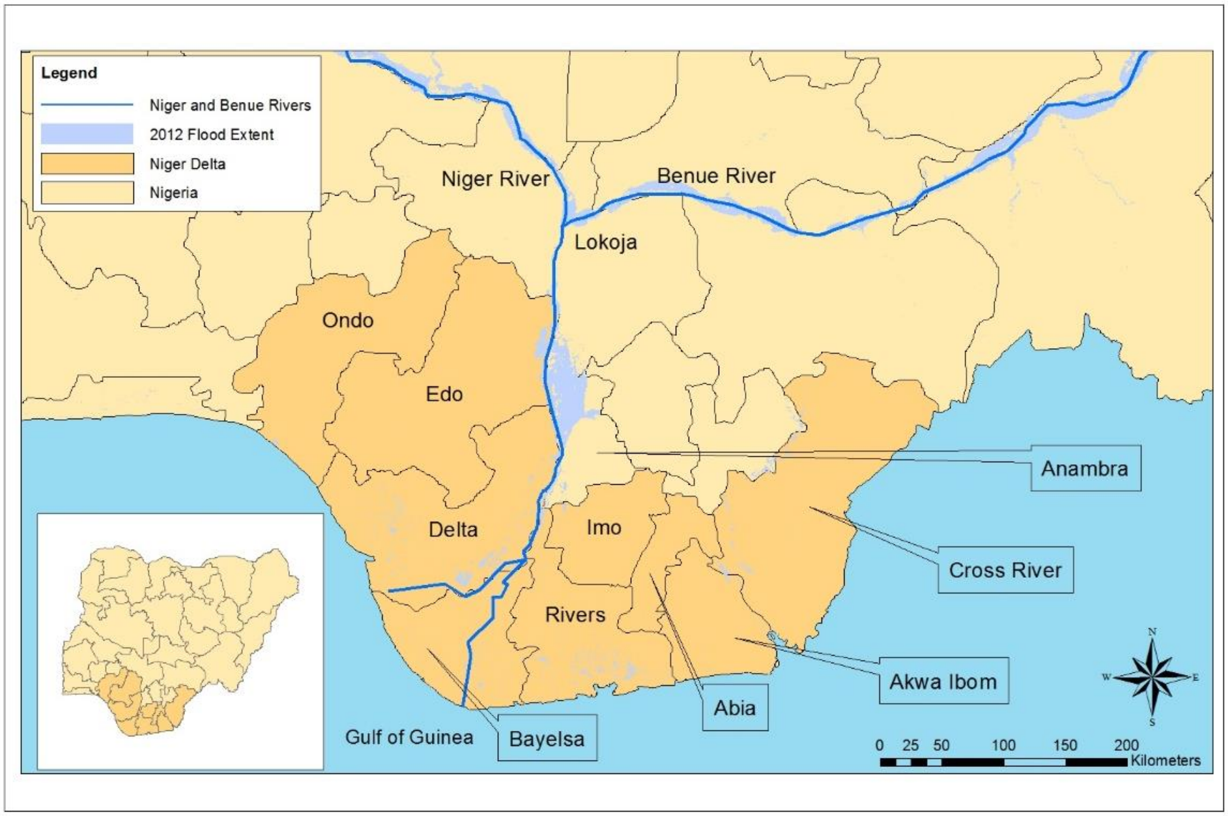
Some studies have found that coastal areas would experience increased rainfall, while interior lands would experience drier conditions (Akitikpi, 1999; Odjugo, 1999; Odjugo, 2005; Niang et al., 2014). It is projected that the west Africa region will have more intense rainfall (Sylla et al., 2012; Haensler et al., 2013; Niang et al., 2014) and a delayed rainy season (Niang et al., 2014), which would have significant impacts on populations engaged in subsistence farming. The Niger Delta, in recent decades, has maintained around 2,900 millimeters (mm) of rain per year (Odjugo, 2005). The duration of rainy days has decreased in recent years in the Niger Delta by approximately 22.0 percent, but there has been an increase in rainstorms by 38.0 percent (Odjugo, 2005). It is the intensity of rainstorms that lead to increased flooding (Ogundebi, 2004), particularly in the Niger Delta (Umoh, 2002; Odjugo, 2005). It is also projected that in the mid to late 21st Century, the southern Nigerian coast will experience one to two more days of extreme rainfall (50mm/day) per year (Nigerian Ministry of the Environment, 2014) – heavy rainfall is considered at 7.62 mm/day.

Furthermore, as global warming occurs and glaciers at the poles melt, a projected one-meter rise in sea-level is projected by 2100 around the world (Awosika et al., 1992; Okali et al., 2004; Amangabara and Obenade, 2015), which would make coastal areas such as the Niger Delta more vulnerable (Ericson et al., 2006; UNDP, 2006; IPCC, 2007; Syvitski et al., 2009; Woodroffe et al., 2012). The coastal vulnerability ranking, which ranks certain physical attributes to determine where the physical effects of sea-level rise will be the greatest, considers the southern Nigerian coast to be at high to very high risk because of the ecological characteristics of lagoons and estuaries (high) and delta, mangroves and barrier islands (very high) (Pendleton et al., 2010; Musa et al., 2014).

The Niger Delta is considered the most vulnerable to flooding in southern Nigeria because of oil industry activities that have degraded the environment and the potential releases of toxic chemicals during flooding (Nigerian Ministry of the Environment, 2014). However, flood protective infrastructure in many communities are absent, which increases vulnerability, particularly during intensive disasters. In 2012, Nigeria had one of the deadliest floods worldwide with the third highest number of people killed (363) and affected (seven million people) (Guha-Sapir and Hoyois, 2013). The managers of the Lagdo Dam on the Benue River in neighboring Cameroon were forced to preemptively release water from the dam due to excessive rainfall, leading to flash floods with the overflow of the Benue River and the connecting Niger River in Nigeria (Federal Government of Nigeria et al., 2013; Agada and Nirupama, 2015) (Figure 2-5 and

Figure 2-6). The Nigerian Meteorological Agency (NIMET) had warned earlier that year that there would be massive flooding and erosion especially in coastal zones and river catchment areas during the rainy season (Agada and Nirupama, 2015). Even with ample advance warning, preparedness was poor and flooding still had devastating impacts in communities along the Benue and Niger Rivers, including the Niger Delta. Tributaries were contaminated and littered with debris, river banks and flood plains eroded, riparian zones were damaged, removing vegetation and exposed soils.

Figure 2-5: Map of Flood Extent in Nigeria.



Sources: National Aeronautics and Space Administration (NASA), 2012 (Flood extent, MODIS image, spatial resolution 250 meter); UNOCHA-Nigeria, 2015 (Flood extent shapefile); Map created by Fatoumata B. Barry, 2018.

Figure 2-6: Before (October 20, 2008) and After (October 13, 2012) Images of Severe Flooding in Nigeria.

October 20, 2008

October 13, 2012

Source: National Aeronautics and Space Administration (NASA), 2012.

Although the Nigerian Government suspects that soils and waterways were contaminated, oil and gas facilities did not provide information about the damage and possible release of toxic chemicals from the flood (Federal Government of Nigeria et al., 2013). The debris and chemicals released potentially damaged ecosystems, particularly mangroves, which act as nets collecting sediments and debris; as well as marine life, which is particularly vulnerable to water contaminants (Federal Government of Nigeria et al., 2013). Flooding may also increase exposure to pollutants from oil spills in waterways and soil, thus augmenting contamination of fresh water and food sources (Osuji and Onoake, 2004; Appel, 2005; Dung et al., 2008). These flood-related conditions have led to adverse health consequences in sub-Saharan Africa with an increased risk of developing skin rashes, ingesting toxic foods, and epidemics of cholera, malaria, and rift-valley fever (Epstein, 2000).

The lack of studies to determine whether the Niger Delta experiences NaTech events is troubling. There is a strong possibility of hazardous substance release into the environment potentially increasing the risks to livelihoods and health of an already vulnerable population. In the United States and Europe, NaTech events normally occur when there is damage to a facility from a natural disaster. However, in the Niger Delta where environmental regulations and policies are lenient, communities are already exposed to oil spills and gaseous releases from oil and gas facilities and increased rainfall and poorly planned infrastructural development has potentially increased the risk of the population to being more exposed. The next section will discuss some of the policy implications and future research needs to determine the magnitude and extent to which communities in the Niger Delta are exposed to hazardous substances from industrial facilities during NaTech events.

2.5. POLICY IMPLICATIONS and FUTURE STUDIES

The impact of natural disasters, intensive and extensive, have increased in frequency and magnitude worldwide with over 700 thousand deaths, 1.5 billion people affected and 1.3 trillion USD loss between 2005 and 2015 (United Nations International Strategy for Disaster Reduction – Regional Office for Africa [UNISDR AF] et al., 2017). Sub-Saharan Africa has endured on average 157 disasters with 10 thousand deaths annually between 2005 and 2015 (UNISDR AF et al., 2017). Women, children, the elderly and disabled were also the most affected during these natural disasters. The international community has encouraged countries to be committed to reducing disaster risks in recent years but have in some cases lacked context-specific guidance to ensure weather-related disaster risk reduction (DRR) is a priority (UNISDR, 2018). This section will focus on the international and regional policies regarding disaster risk reduction, the Nigerian government's priorities in reducing disaster risks and the future research needs to ensure increased attention on the impacts of intensive and extensive disasters and NaTech events in communities close to oil and gas industry activities in the Niger Delta in Nigeria are met.

2.5.1. International, Regional and National Policy Implications in Disaster Risk Reduction

International commitments to reducing disasters have increased in recent years particularly with the development of the Sendai Framework, a voluntary, non-binding 15-year agreement adopted in 2015 to reduce disaster impacts by 2030. There are 47 African countries that have signed the Sendai Framework and have developed a Strategic Program of Action to align priorities and targets. Natural disasters are not only linked to weather-related events such as El Niño, which affected rainfall patterns and temperatures in various parts of sub-Saharan Africa resulting in increased flooding and droughts, but health-related outbreaks such as Ebola also had significant impacts on the population (UNISDR AF et al., 2017).

During the African Union Summit in January 2017, African countries signed the Mauritius Declaration to ensure strong political commitments to implement the Sendai Framework and to allocate budgetary support to DRR (UNISDR AF et al., 2017). However, one key element was absent in the discussions of DRR in sub-Saharan Africa until recently, which is the impact of industrial accidents during weather-related disasters (UNISDR, 2018). In early 2018, the United Nations International Strategy for Disaster Reduction (UNISDR) developed a public consultation and review document in order to obtain suggestions and recommendations from the DRR community to provide guidance regarding man-made and technological hazards to improve the implementation of the Sendai Framework (UNISDR, 2018). This included a focus on extensive disasters and the need to account for potential NaTech events in sub-Saharan Africa. In the European region, the Convention of Transboundary Effects of Industrial Accidents was signed in Finland in 1992 and went into force in 2000 with the aim to protect the environment and populations against industrial accidents particularly in a transboundary context (UNECE, 1992, 2000; UNECE, 2017). Regrettably, this Convention does not apply to oil spills and other harmful substances offshore or at sea caused by natural disasters. It is also unclear whether industrial accidents caused by States that are signatories to this Convention are also liable for the transboundary effect of industrial accidents in non-signatory States.

At the national level, the Nigerian Government has instituted a National Disaster Management Framework, which guides the National Emergency Management Agency (NEMA) in effective and efficient disaster management in Nigeria (Ezeigbo and Picard, 2012). There is also an early warning system developed for floods under the Ministry of Environment to ensure proper outreach to communities, but it is unclear how effective it has been (Ezeigbo and Picard, 2012). The Nigerian Government has focused on increasing gender mainstreaming in DRR activities and the use of indigenous knowledge and science and technology to develop DRR solutions (Federal Government of Nigeria et al., 2013). Decentralization of DRR activities is also a priority in Nigeria and the Federal Government is committed to allocating funds for DRR activities in all tiers of government (Environews Nigeria, 2017). Dodman et al. (2012) explain that the effectiveness of local governance is a key component in reducing disaster risks particularly as it relates to poverty. The researchers found that when local governments are empowered and given the appropriate financial support, they can reduce poverty in their municipalities, in effect removing the relationship between low-income and extensive disaster risks.

However, official statements from the Nigerian Government at international DRR conferences are reported to mostly focus on the Boko Haram Insurgency and less so on the impact of weather-related disasters in the country (Federal Government of Nigeria, 2015, 2017). Furthermore, Environmental Impact Assessments (EIAs) in Nigeria do not include any guidelines to assess how natural hazards will impact private or public development/facilities (Ezeigbo and Picard, 2012). The EIAs mostly focus on human risk factors or impacts on the environment due to the activities proposed. The National Environmental Standards and Regulations Enforcement Agency Act of 2007 also has a mandate to ensure compliance with international and national environmental laws primarily concerning the protection of the environment through biodiversity conservation and sustainable development and ensuring proper sanitation and reduction in pollution (Ezeigbo and Picard, 2012). However, this Agency was not tasked to prevent or investigate cross-contamination, such as the effect of flooding in areas with oil spills (Ezeigbo and Picard, 2012). The National Oil Spill Detection and Response Agency (NOSDRA) was established in 2006 to ensure preparedness and response to oil spills in Nigeria (Kadafa et al., 2012). They developed a hotline where citizens can call in to report oil spills and they have developed a website that provides a map with the location of oil spills disaggregated by the cause (oil company or third party) and whether the spills have been cleaned up. It is unclear whether local communities are informed when oil spills have occurred and whether they also investigate oil spills after flooding events. Therefore, it is important that more research studies are conducted related to natural disasters and their impacts in oil-producing regions in Nigeria in order to encourage the Nigerian Government to focus on reducing natural disaster risks and potential NaTech events to ensure future environmental preservation and the health of the people and their communities living in the Niger Delta.

2.5.2. Future Research Needs

There are a number of research studies that are needed to better understand intensive and extensive disasters and NaTech events in sub-Saharan Africa in general, and Nigeria, in particular. First and foremost, there is a lack of transparency from industrial facilities in the aftermath of natural disasters (Cruz and Krausmann, 2009; Federal Government of Nigeria et al. 2013). It will be important to determine whether oil and gas extraction activities are releasing hazardous chemicals prior to and in the aftermath of natural disasters in the Niger Delta. It is also critical to determine health and livelihood risks associated with oil spills and gas flare emissions prior to flooding. Although intensive risks from the 2012 flooding event have been investigated, oil and gas companies did not provide any information about the releases of hazardous oil and gas substances during the flood or in its aftermath (Federal Government of Nigeria et al., 2013). There are also limited data on the link between extensive disasters and NaTech events in the Niger Delta. Therefore, future research needs to assess the potential impacts if hazardous releases occur during recurring and intensive flooding events in the Niger Delta. Future research should also determine the extent to which intensive disasters occur in areas with extensive disasters in the Niger Delta to assess the similarities and differences in the livelihood and health implications.

It will also be important to determine the groups that are most at risk during flooding events in the Niger Delta. Previous studies have shown that women, children, the elderly and disabled may be more vulnerable than men during flooding events (Amangabara and Obenade, 2015; Enete et al., 2016). Women have and continue to be deprived of access to property and credit because of traditional customs, putting them and their children at greater risks during emergencies (Nwoye, 2007). Women also tend to focus on food crops, which are more likely to be devastated during natural disasters (Nwoye, 2007). In many sub-Saharan African countries, traditional customs from the pre-colonial and colonial eras have shaped the gender divisions of labor, resources, responsibilities, and power (Okpara, 2006; Ogunlela and Mukhtar, 2009). Although the Nigerian Constitution of 1999 has provided equal rights to all under the law, communities tend to have patrilineal systems where women are granted access to the land because of their responsibilities for food production and caring for children, but the land is owned by their husband's family (Ogunlela and Mukhtar, 2009). Thus, future research should include the relative impacts and burdens of the climate variability/oil exploitation nexus on women and men, and the relative contributions of women and men to current adaptation strategies, in order to identify and more effectively target better solutions to flooding events.

Research will also need to consider the future projections of climate variability and sea-level rise on natural disasters in the Niger Delta. Various climate change models are projecting increased temperatures, precipitation and sea-level rise in certain regions, which will have detrimental impacts on populations. The coastline (500km) between Accra (Ghana) and the Niger Delta will become increasingly populated with more than 50 million inhabitants by 2020, which will increase the number of vulnerable people due to rising sea levels and increased rainfall (Hewawasam, 2002; Ajibade et al., 2015). It is projected that 80.0 percent of the population in the Niger Delta will have to be relocated due to severe flooding (Awosika et al., 1992; Okali et al., 2004). It is, therefore, important to determine what the future risks are for a region with an increasing population and potentially more intense weather patterns.

2.6. CONCLUSION

Natural disasters cannot be separated from the social, political and economic factors of a region (Wisner et al., 2004). The vulnerability of an area is not only explained by its environmental characteristics or the natural hazards it experiences, but it is also closely intertwined with the lack of policies and their implementation that would reduce the vulnerability of a population (Wisner et al., 2004). The impacts of natural disasters are growing around the world and there are even more threatening in regions with pre-existing vulnerabilities. Although natural disasters tend to be linked to intensive disasters, there are hundreds of extensive disasters that devastate areas for every intensive disaster. Flooding is one of the major natural hazards that is observed in sub-Saharan Africa that has led to a number of extensive and intensive disasters. Regions that are not only exposed to flooding, but also have industrial facilities are at even greater risk because of the potential releases of hazardous substances, also known as NaTech events. During floods, industrial facilities are quite vulnerable if protective measures are not taken to secure storage tanks and other infrastructure (Krausmann and Mushtaq, 2008). The hazardous releases and debris and toxic chemicals dispersed into the environment from flooding have various short- and long-term livelihood and health consequences. Flooding can become even more hazardous in regions of the world where there are pre-existing vulnerabilities such as widespread poverty, inequalities, and poorly planned infrastructural development. Some scholars blame structural adjustment programs in the 1980s in sub-Saharan Africa and other regions in the Global South for limiting the abilities of national governments to build the necessary protective infrastructure for improved standard of living (Hamdan, 2015).

The combined effects of natural (increased rainfall) and anthropogenic factors (oil extraction and poorly planned infrastructural development) are the primary drivers of flooding and human vulnerability in the Niger Delta. In 2012, Nigeria experienced excessive flooding due to increased rainfall and the release of excess water from the Lagdo Dam in neighboring Cameroon into the Benue River that flows westward into Nigeria (Federal Government of Nigeria et al., 2013; Agada and Nirupama, 2015). The lack of transparency from the oil and gas industry on oil spillage and hazardous substance release prior to, during and in the aftermath of this flooding event makes it difficult to determine whether the population was exposed to hazardous substances. Also, due to the severity of the 2012 flood, some scholars would argue that the lack of protective measures to deal with recurring floods (extensive disasters) in the Niger Delta may have led to this intensive disaster.

The international and regional communities have in the last decade encouraged countries to allocate resources to fund disaster risk reduction (DRR) activities and to include local populations in the planning processes. However, it is only in recent years, that they have provided guidance to countries on NaTech events from intensive and extensive disasters in sub-Saharan Africa but to date there is virtually no research documenting the magnitude and extent of these events in this region. National legislation in Nigeria regarding NaTech events are absent and therefore, future research must focus on the potential environmental, livelihood and health implications of intensive and extensive disasters in communities close to oil and gas facilities. This will enable Nigeria and other countries in the sub-region under similar conditions to develop context specific solutions for DRR while maintaining and improving the health and livelihoods of their communities.

There should also be a focus on the most impacted groups, such as women and children, in communities that experience the dual hazards of oil pollution and severe flooding. These priorities will enable sustainable preventative and adaptive measures to be at the forefront of present and future initiatives. If measures are not taken soon, populations in Niger Delta communities will continue to become displaced, which will lead to a greater crisis not only due to the ecological degradation of the wetlands and mangroves but also migration, producing a perfect storm where violence and conflict can take foot as competition for increasingly limited resources needed to survive intensifies. In sum, flooding due to climate variability and poorly planned development in Niger Delta oil-producing communities is an emerging threat that not only affects ecosystems, homes and livelihoods, but it may also potentially increase the risk of disease (Barry and Grady, forthcoming). It is therefore imperative that special attention be given to these communities in order to improve their standard of living to enable them to live long, healthier lives.

CHAPTER 3

AFRICANA WOMANISM AS AN EXTENSION OF FEMINISM IN POLITICAL ECOLOGY OF HEALTH RESEARCH

ABSTRACT

A feminist perspective within political ecology and political ecology of health considers gender dynamics in the use of environmental resources, labor division, and health inequalities. However, a feminist perspective may not adequately engender the perspectives of Africana women as many embrace their roles of the nurturer, protector and provider of their families. Africana womanism, an African theoretical perspective that is family-centered and focuses on women's concerns only after the community's needs are met, provides a different lens by which to conduct research in sub-Saharan Africa. However, in today's reality, Africana womanism cannot remain isolated. This chapter focuses on the importance of the inclusion of Africana womanist perspectives in political ecology and political ecology of health research by linking African feminism and Black feminism, which are grounded in the multiple oppressions that Africana women historically and currently face, to Africana womanism and feminism. These multiple perspectives from Africana women will enable a better understanding of gender dynamics in sub-Saharan Africa and will enable Africana womanism to be used as an extension of feminism to account for a uniquely Africana perspective in political ecology and political ecology of health research.

3.1. INTRODUCTION

With the introduction of political ecology, researchers had a theoretical framework by which to study the complexities of social, economic and political decisions and their implications on populations and the environment in the Global South (Bryant, 1997, 1998; Robbins, 2012). political ecology emphasizes the nature and impacts of power structures, such as the unequal relations of power among individuals and societies, as well as laws and policies, and how they shape the management and control of environmental resources, often including the marginalization and oppression of certain groups (Bryant, 1997, 1998; King, 2010; Robbins, 2012). From this framework, a gendered perspective emerged, feminist political ecology, as a lens by which to include the voices of women, to further understand the gendered dynamics in the use of environmental resources and labor patterns (Rocheleau, 1995; Rocheleau et al., 1996; Nightingale 2006; Elmhirst, 2011; Jackson and Neely, 2014). In addition to the breadth and depth of political ecology and feminist political ecology, several researchers in recent years have acknowledged the need to further examine the political ecology of health (Walker and Bulkeley, 2006; Singer, 2009; King, 2010), with the inclusion of a gendered perspective in understanding health disparities (Jackson and Neely, 2014). The political ecology of health provides an improved understanding of how decisions that transform the natural environment, often produced by Western-controlled political and economic systems, increase inequality in communities in the Global South. This includes exposing certain population groups to unhealthy conditions that transform and spread diseases, resulting in poor population health. However, similar to political ecology, the political ecology of health initially lacked a gendered perspective. By recognizing a combination of marxism and feminism to address systems of discrimination and uneven power relations, political ecology of health research and solutions is strengthened to reduce health inequalities, as long as intersectionality, which acknowledges the multiple systems of oppression on certain population groups ranging from racism, classism to sexism, is also embraced (Rocheleau et al., 1996; Valentine, 2007; Few, 2007; Elmhirst, 2011; Mollet and Faria, 2013; Jackson and Neely, 2014).

This chapter argues that a gendered perspective in political ecology and political ecology of health does not fully acknowledge the unique gender roles in countries of the Global South—in particular sub-Saharan African countries, where gender roles were atypical of Western contexts prior to and during colonialism (Hudson-Weems, 1993; Oyewumi, 1997; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008). One perspective that represents gender dynamics prior to colonialism in sub-Saharan Africa is Africana womanism. As an African theoretical perspective, Africana womanism contends that in times of hostility, many Africana women will highlight historical oppression (racism) before sexism and community and family needs before individual needs, as individual needs are a colonial, patriarchal and westernized concept (Hudson-Weems, 1993; Oyewumi, 1997; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008; Pellerin, 2012). Therefore, when issues arise within a community, Africana womanists will cite how the community is affected as a whole since Africana women and men are victims of oppression. In political ecology and political ecology of health research in sub-Saharan Africa, understanding the diversity of thought is important to develop and conduct better research. Linking Africana womanism to feminist political ecology by engendering African feminism and Black feminism is critical as it allows various interpretations of research findings to be made in order to have a more holistic picture. However, there are limited political ecology and political ecology of health studies that address the multiple oppressions that women face in the Global South (Mollet and Faria, 2013). In sub-Saharan Africa, this could be a result of the lack of emphasis in the field of political ecology on African theoretical perspectives that would provide an improved understanding of studies conducted on women, environment and health.

The purpose of this chapter is to inform researchers, particularly researchers of political ecology and political ecology of health, to "re-think" and "re-shape" the ways in which they conduct research about gender dynamics, the environment, and health in sub-Saharan Africa. It is proposed that there are preferred or alternative ways to conduct political ecology and political ecology of health research related to gender in sub-Saharan Africa that specifically captures the complexities of human relationships in their distinctive cultural context. An alternative approach would be to link Africana womanism to feminism, creating a gendered Africana perspective that acknowledges the complexities of African traditions and the influence of Western ideologies in Africana cultures that are vast and cannot be ignored. This chapter begins with a literature review unpacking political ecology, political ecology of fealth, feminist political ecology, and Africana womanism. It is followed with an explanation of African feminism and Black feminism and how these two theoretical perspectives can potentially link Africana womanism to feminism in political ecology and political ecology of health research. The chapter concludes by supporting Africana womanism as an extension of feminist political ecology and the importance of using multiple lenses to reduce the essentialism that is occasionally observed when conducting research in sub-Saharan Africa.

3.2. LITERATURE REVIEW

3.2.1. Political Ecology (of Health)

Over the last couple of decades, many scholars have begun to re-focus their attention on political, economic and social world systems and how they impact populations and ecological systems, particularly those located in the Global South (Bryant, 1997, 1998; Robbins, 2012). Also known as political ecology research, scholars have conducted ample studies to understand how Western-controlled global economic and political systems are negatively impacting developing countries' political systems, economies and environments, which result in the marginalization and oppression of certain population groups (Bryant, 1997, 1998; Robbins, 2012). Political ecology examines the power relationships that reinforce inequities in decision-making at various scales (Bryant, 1997, 1998; King, 2010; Robbins, 2012). The relationship between politics and ecology is not an equal one as the role politics plays in shaping ecology today is much greater than in the past (Bryant, 1997).

Bryant (1997) further explains that global capitalist systems take advantage of communities that have unequal power relations and excessive inequalities in developing nations. Power, which resides in the political and economic structures, is important in understanding unequal relationships in the struggle to access and use environmental resources in developing nations (Bryant, 1997; King, 2010). Therefore, political ecology research in developing countries can clarify the political basis of many contemporary environmental problems and how politics should be prioritized when attempting to understand how human-environment interactions may be linked to environmental degradation.

Political ecology also attempts to determine how and why conflicts over access and the use of environmental resources are linked to international and national systems of economic and political control (Bryant, 1998). According to Robbins (2012), there are five main themes of political ecology:

1) degradation and marginalization –efforts to improve production systems often result in unsustainable decision-making, blaming of marginal people, and inequality (i.e., reflection on Neo-Marxist theories of social justice and equity);

2) environmental conflict –changes in social and environmental practices can cause conflict and are part of a larger class, racial and gender struggle;

3) conservation and control –interventions by conservation and development agencies marginalize livelihood systems of local populations and criminalizes traditional practices;

4) environmental identity and social movements –the emergence of political organizations and movements that connect seemingly disparate groups to more powerful economic and political agendas; and

5) political objects and actors –political and economic systems are affected by non-human actors, leading to further injustices.

All five political ecology themes are observed in many communities in the Global South. However, political ecology has not focused enough on health inequalities and therefore, the political ecology of health needs to be examined more closely (Walker and Bulkeley, 2006; Singer, 2009; King, 2010).

The political ecology of health suggests that global political and economic structures reinforce health inequities in low-income and historically marginalized communities, particularly those located in the Global South. This perspective provides a better understanding of the interactions between poverty and structural inequalities and how they increase the burden of disease in vulnerable populations (Singer, 2009; Jackson and Neely, 2014). There are three major inter-related components to the health consequences of social and economic inequality: (1) historical marginalization of populations; (2) restructuring of nature; and (3) the human body's vulnerability (Baer and Singer, 2009; Jackson and Neely, 2014). A description of these three inter-related components of the political ecology of health framework follows.

First, population groups that have been historically marginalized have higher levels of poor health (Baer and Singer, 2009). This is due to a variety of factors such as life-long exposure to discrimination, unemployment and economic deprivation, which independently and cumulatively increases their vulnerability and susceptibility to certain health conditions. Turshen's (1984) study in Tanzania examined how the presence of colonial rule impacted the local economic system, which resulted in an increase in disease because of segregation policies that forced the local population to obtain healthcare in substandard hospitals, while colonialists had access to high quality healthcare. In the Global North, the high prevalence of certain health conditions and diseases in African-Americans in the United States appears to reflect a historic structure of social inequality due to racial residential segregation, poorer living and working conditions, sub-standard treatment by those in power, and reduced access to quality health services (Baer and Singer, 2009). For instance, a study conducted by Dressler (1993) found that United States-born African-Americans had a significantly higher prevalence of hypertension compared to other groups of African descent such as West Africans, Afro-Caribbeans, Afro-Brazilians, and Afro-Europeans, which suggests that social rather than biological factors may be responsible.

Second, the ability for humans to restructure nature through development activities, also referred to as ecological simplification, has forced certain populations to live and work in environments with greater exposure to environmental toxins, leading to acute and chronic health conditions (Baer and Singer, 2009). Communities with a heavier presence of industrial facilities have higher rates of environmental health risk factors (Harper, 2004; Ana et al., 2009; Ajayi et al., 2009; Gobo et al., 2009). For example, Gobo et al. (2009) found that a rural oil community had higher rates of respiratory irritants than a rural non-oil community in the Niger Delta region of Nigeria. These are communities that lack basic services such as electricity, piped water and roads.

However, the mere exploitation and extraction of oil resources has led to ecological degradation and adverse health consequences from oil pollution in the form of oil spills and gas flares (Gobo et al., 2009; Ana et al., 2009; Ajayi et al., 2009). Gas flares, which involve the induced combustion of volatile organic compounds (VOCs) in which the gases are piped and then burned in an open flame, are a major contributor to environmental irritants as they release various harmful substances. The substances released from the flares are known to cause respiratory problems, skin/eye irritation, cancer, birth defects and affect productivity (e.g., through disturbance of the wake-sleep rhythm, which makes individuals lack energy) (Gobo et al., 2009; Ana et al., 2009). Ecological simplification can also lead to a variety of vector-borne diseases including malaria, Human Acquired African Trypanosomiasis and schistosomiasis and many other neglected tropical diseases in sub-Saharan Africa.

Health of women and children is also deeply intertwined with space as health is linked to where one lives. For instance, the Niger Delta has the highest human immunodeficiency virus (HIV) sero-prevalence rate in Nigeria (Nigeria Federal Ministry of Health, 1999; Udonwa et al., 2004). This is mostly a result of male employees from multinational oil companies interacting with women in communities in proximity to their oil station operations—a result of the lack of sexual education and poverty (Udonwa et al., 2004; Okonta, 2007). In terms of children's health, Bruederle and Hodler (2017) found that infant deaths were highly linked to oil spills in the Niger Delta. Infants born within 10.0 km of an oil spill that occurred prior to the mother's conception had double the prevailing neonatal mortality rates, reaching approximately 78.0 deaths per 1,000 live births (Bruederle and Hodler, 2017). In 2012, 70.0 percent of the 16,000 neonatal infants (first month of life) who died would have survived if the mother had not lived close to an oil spill, according to Bruederle and Hodler (2017).

Last, the human body is vulnerable to pathogens (Castree, 2002; Jackson and Neely, 2014). Thus, social and environmental conditions and stressors that adversely impact the body before or after the intrusion of agents or toxins will further compromise the immune system –i.e., increasing susceptibility to diseases that can lead to premature mortality (Baer and Singer, 2009). This phenomenon at the population level is also known as syndemics, the cause(s) underlying the multitude of infectious and chronic diseases triggered (epidemic) and sustained (endemic) in a population because of marginalization, unemployment, economic deprivation, structural violence, and exposure to toxic environments (Singer and Clair, 2003; Baer and Singer, 2009; Jackson and Neely, 2014). For example, during the 1992 civil war in Somalia, children's immune systems were compromised by a combination of the social stress of war and relocation to internal displaced camps (Ostrach and Singer, 2013). Subsequently, contaminated food supplies and diarrheal diseases increased malnutrition two-fold in children in the camps (Moore et al., 1993; Ostrach and Singer, 2013). These impoverished conditions led to the death of 74.0 percent of children under the age of 5 years (46 out of 62 children) in the camps (Moore et al., 1993). It is therefore, the interactions of risk factors and the array of diseases found in children, rather than battlefield injuries that caused the majority of child casualties of war (Ostrach and Singer, 2013).

3.2.2. Feminist Political Ecology (of Health)

The feminist political ecology theoretical perspective posits that political ecology needs to be more inclusive of the gendered dynamics of the use of environmental resources and labor divisions (Rocheleau, 1995; Rocheleau et al., 1996; Nightingale 2006; Elmhirst, 2011). Feminist political ecology scholars contend that there is a link between gender and environmental issues, and development processes, but there is still much research needed to determine the nature of these complex relationships (Rocheleau, 1995). It is clear, however, that feminist political ecology scholars want to change the perceived notion that "Women are 'at home' and men are 'at the workplace'" (Rocheleau, 1995). Social interpretations of biology and social constructs has led to the perceived hierarchy of men, which has misrepresented the value and worth of women (Elmhirst, 2011) and has re-enforced normative gender roles that are not observed or desired everywhere (Rocheleau, 1995; Rocheleau et al., 2006).

Furthermore, feminist political ecology is a female-centered theory, which contends that women are as much involved in daily social and economic activities as their male counterparts (Rocheleau, 1995; Nightingale 2006; Elmhirst, 2011). For example, in many countries, women are responsible for the production of daily subsistence, the knowledge of complex ecosystems (agriculture, livestock, forestry, and fisheries) and ultimately, the addition to the workforce through births into the population (Rocheleau, 1995; Nightingale 2006). Yet, these same women are often landless, not officially part of the formal work force, and their productivity is not 'counted' into many economic measures (e.g., gross national product [GNP], gross domestic product [GDP], etc.). The international development community in its aim to promote inclusion of women have also missed the mark by developing programs that maintain traditional roles of women such as their responsibilities to care for the environment, thereby exacerbating social and gender injustices (Elmhirst, 2011). Feminist political ecology is also not exclusively limited to gendered dynamics but attempts to understand uneven power relations and other forms of discrimination (e.g., racism and classism) in the use, perception, and control of resources and how these transform a society's landscape, social organizations, and livelihood activities (Rocheleau, 1995; Elmhirst, 2011).

Marxist-Feminist approaches add another layer, particularly to the political ecology of health (described above) by focusing on how global political and economic structures shape the way people experience, understand and make decisions about health (Jackson and Neely, 2014). Gatrell and Eliott (2014) state that, "In the end, humans make their own health, but not in the conditions of their choosing." For instance, structural adjustment programs and increasing incidence rates of human immunodeficiency virus (HIV) infection in Malawi in the 1980s to 1990s have led to a number of problems for farmers and their families (Craddock, 2001; Gatrell and Eliott, 2014). Fertilizer subsidies were removed in the late 1980s, which forced some farmers to reduce the amount of maize grown to be sold, thus reducing family income and leading to poorer female heads of households to engage in commercial sex work to supplement their incomes (Craddock, 2001). Furthermore, due to power asymmetries, women in Malawi and many countries around the world do not have the leverage to force the use of condoms, which unfortunately has led to higher rates of sexually transmitted infections and HIV (Craddock, 2001).

In summary, it is important to include a feminist lens in political ecology and the political ecology of health research; otherwise there will be many unanswered questions when developing solutions to inequality and injustice in the Global North and South. However, this chapter addresses one of the questions that remain: is feminism enough to address the gendered concerns in all societies around the world?

3.2.3. Africana Womanism

To answer this question in an African context, it would be important to understand local culture, customs and traditions prior to engendering a feminist approach to political ecology and political ecology of health research. Such an understanding suggests that the feminist perspective does not adequately address Africana women's experiences and needs. An alternative to the feminist perspective is Africana womanism (Hudson-Weems, 1993; Joyce, 2001; Alexander-Floyd and Simien, 2006; Pellerin, 2012). Africana womanism is a family-centered perspective that specifies that women's needs are only accounted for once the needs of the family/community as a whole have been addressed (Hudson-Weems, 1993; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008). According to Hudson-Weems (1993), Africana womanism offers four reasons to reject the feminist perspective: 1) Africana women need to reclaim the discourse by self-naming and self-defining, 2) the feminist movement does not account for the needs of Africana women in their doctrines, 3) white feminists have different struggles and expectations than Africana women, and 4) feminism appears to be inherently racist as it operates within white feminists' causes. In essence, white feminists' overall goal is to claim equality with their white male counterparts; a right that they were unable to have historically because they were ignored and considered property (Hudson-Weems, 1993). White feminists in the early 20th Century believed that the institution of family in itself made women subordinate and restricted them from participating in public life unlike men (DuBois, 1975). In contrast, Africana womanists do not need the same sense of equality that white feminists desire in relation to their husbands in general and men in particular, as Africana women did not experience the same type of longstanding institutional oppression from Africana men (Hudson-Weems, 1993; Joyce, 2001). The sexism from Africana men towards Africana women that may be felt in recent times, is a result of the historical oppression of African men and women from white men and women. Thus, the overall goals of white feminists and Africana womanists may be slightly similar, but priorities are different due to the impact of oppression on Africana families.

Africana men and women share a racially oppressed history, which creates unique priorities and struggles (Hudson-Weems, 1993; Joyce, 2001; Alexander-Floyd and Simien, 2006; Mweseli, 2007; Pellerin, 2012). Joyce (2001) posits that black women must engage white racism, white male sexism, and black male sexism; in that order. In other words, Africana women must fight for recognition from multiple angles beginning with the racism that their black families experience as a whole and then the sexism that they, as black women, experience from white men and, as women, from black men. Africana womanists embrace gender roles that were in place prior to colonialism (Hudson-Weems, 1993; Joyce, 2001; Pellerin, 2012). Also, Africana womanists consider men as victims of patriarchy and oppression. For instance, in the mid to late 19th Century, the Woman's Suffrage Movement led by Susan B. Anthony and Elizabeth Cady Stanton in the United States, which is known today as the Feminist Movement, protested to abolish slavery and to ensure equal rights for all people, regardless of sex, race or class (Hudson-Weems, 1993; Newman, 1999). However, when the 15th Amendment gave the right to vote to Africana men and excluded women, many white feminists were dismayed, leading them to take a more radical stance to become full citizens (Hudson-Weems, 1993; Newman, 1999). A few years later, the National American Woman Suffrage Association (NAWSA) was founded on this radical viewpoint and attempted to obtain the right to vote for white middle-class women by promoting the idea that white women needed to aid their husbands in preserving the values of American society from unqualified and biologically inferior persons (Africana men) (Hudson-Weems, 1993). The Woman's Christian Temperance Union (WCTU) also played a very important role in getting white women the right to vote (DuBois, 1975) even if one of the methods was to vilify black families with similar messages as the NAWSA (Newman, 1999). Some white feminists did not believe that Africana men should have the right to vote before them and even after women gained the right to vote in the early 20th Century, white feminists were still reluctant to discuss race within the Movement (Hudson-Weems, 1993). This is mainly a result of the indoctrination of racism and classism in the Feminist Movement as many of their followers believed that this Movement was for educated, middle-class white women.

Another example of the oppression Africana men and woman faced is how language was colonized on the African continent. Gender distinctions were not the norm in various African languages (Oyewumi, 1997). In Yoruba, a language primarily spoken in Nigeria, age is the most important distinction. However, European influence on the African continent changed this as it was necessary for the advancement of a colonialist agenda to have gender-specificity to alienate African women as they were seen as a threat (Oyewumi, 1997). One example of this view is when European colonialists opened schools in Africa and forbade girls, especially pregnant girls, from attending (Joyce, 2001). Therefore, when examining oppression brought about from colonialism, language played a role in creating two distinct groups in African societies, which resulted in the emasculation of Africana men and sexism (Joyce, 2001). Africana men have been manipulated and have been expected to engender sexist ideals to promote colonialism at the expense of the progression of their own communities (Joyce, 2001). European colonialists that came to the African continent promoted patriarchy and would only work with men who engaged in sexist ideals (Joyce, 2001). Today, many Africana men continue to espouse these sexist beliefs as they feel it is a way to maintain the equality that they once felt before the arrival of the Europeans. Consequently, Africana women are put at a disadvantage and Africana men, who still are a part of their struggles, have become more individualistic at the detriment of Africana family values (Joyce, 2001). Additionally, it is reinforcing the continued oppression that was instituted during colonialism, which will therefore continue to leave Africana women out of major decisions such as those that need to be made about environmental resources and the future of their communities. Thus, Africana men are as oppressed as Africana women due to institutionalized systems that have overpowered Africana families mostly led by white men (Hudson-Weems, 1993; Joyce, 2001).

White women also played a role in maintaining the oppression of Africana families and as a result, Africana womanism cannot be brought under the auspices of feminism.

3.2.3.1. Does Eco-Feminism Engender Africana Womanism?

Some scholars may believe that Africana womanism can be housed under the eco-feminist theoretical perspective, particularly when discussing environmental affairs (Nightingale, 2006). Eco-feminism posits that there is a natural connection between women and nature, which gives women an innate understanding of ecosystems and environmental protection (Warren, 1987; Nightingale, 2006). Similarly, Africana womanist scholars find that, "…Africana women come from a legacy of fulfilling the role of supreme Mother Nature –nurturer, provider, and protector" (Hudson-Weems, 1993). However, there are two major problems with eco-feminism for Africana womanism: 1) it is female-centered and 2) it is in constant battle to become the central perspective within feminism (Nightingale, 2006; Iromuanya, 2008). Under eco-feminism, women are victimized because they are closer to nature and therefore, when decisions are made about environmental resources without their input, they are put at a disadvantage psychologically, socially, and economically (Warren, 1987; Nightingale, 2006).

Feminist political ecology distinguishes itself from eco-feminism as it contends that eco-feminism is linked to the oppression guided by patriarchy, which regards women as emotional and nurturing, while men are rational and competitive (Nightingale, 2006). Africana womanist scholars do not believe that being emotional or nurturing is a negative value and the idea that rationality and competitiveness are stronger traits are the biases promoted by patriarchy. In addition, the environment is a matriarchal entity and women reproduce children, male and female, that together have the responsibility to care for the earth (Iromuanya, 2008). Africana womanism, as a family-centered perspective, contends that men are also victims of patriarchy, not just women. In many

African communities, men see themselves as sons first (family-oriented –extension of their mothers), before their sex/gender identity as male/man (independent, autonomous being) (Iromuanya, 2008). Therefore, Africana womanism cannot be housed under eco-feminism as it also engenders a feminist perspective that does not account for an Africana perspective.

Nevertheless, Africana womanism would be quite fitting if used as an extension of feminist political ecology when conducting research. These two theoretical perspectives have one common goal; to ensure that women's perspectives are included when conducting research and analyzing results. However, these two theoretical perspectives have different ways of engendering the female voice as feminism is strictly requiring that women's needs are accounted for (Rocheleau, 1995, Rocheleau et al., 1996; Nightingale 2006; Elmhirst, 2011), while Africana womanism only accounts for women's needs once the needs of the family/community as a whole have been addressed (Hudson-Weems, 1993; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008; Pellerin, 2012). Within feminism, however, African feminism and Black feminism have emerged, which also provide different perspectives on Africana women and their families. It would be important to determine whether Africana womanism can be used as an extension of feminist political ecology when conducting research if other African feminist theoretical perspectives are included within the framework.

3.3. EXTENDING AFRICANA WOMANISM

When conducting research, multiple perspectives are useful in limiting misrepresentations of findings. It is critical to be cognizant of our biases as researchers and how they may impact, consciously or unconsciously, the way research questions are developed and results are analyzed. This is particularly important when conducting research in rural communities in sub-Saharan Africa as views that are common place in urban settings and in other countries may not be engendered in these communities (Hacker, 2013; Casale et al., 2013). Hudson-Weems (1993) who coined the term, Africana womanism, was not keen on linking Africana womanism to any westernized theoretical perspective, including feminism for the reasons described above. However, today, Africana womanism cannot remain isolated with western values expanding, inter-mixing of communities and families, and the impacts of slavery and colonialism on people's attitudes, beliefs and values. Many Africana communities have changed, and some find themselves closer to a centric view between Africana womanism and feminism where African feminism and Black feminism lie. If African feminism and Black feminism are emphasized in feminist political ecology, Africana womanism could be used as an extension to provide a more holistic understanding of gender dynamics in environmental resources, labor divisions and health inequalities in sub-Saharan Africa.

Black feminism and African feminism are two theoretical perspectives that are borne out of the Feminist Movement but are rooted in the experiences of Africana women. In the United States, Black feminism is based on the multiple oppressions that black women face because of their race, ethnicity, gender, sexual orientation and class and also rejects white feminism due to its inability to address the concerns of black women (Combahee River Collective, 1977; Collins, 1991; Few, 2007). Black feminism also acknowledges the support that black women provide to keep their families intact and that black men and women have common struggles in combating institutional racism and classism (Few, 2007). African feminism is rooted in indigenous African cultural perspectives, African geo-political location and an African ideological viewpoint and presents unique perspectives on the need for gender inclusion, collaboration, and accommodation of both men and women to improve the material condition of women (Kolawole, 2004; Nkealah, 2006, 2016). In essence, if the conditions of African women are improved, the family and community will reap the benefits. Similar to Africana womanism and Black feminism, African feminism rejects white feminism because it sees men as the enemy and the experiences of African women are not prioritized in the Feminist Movement (Nkealah, 2016). There is also a diversity of thought within African feminism; some that include Africana womanism's tenets such as:

1) Stiwanism, which criticizes the oppression of African women because of their roles as wives and the colonial and neo-colonial structures that have put African men above African women; leaving out African women in the diaspora (Ogundipe-Leslie, 1994);
2) Motherism, which entrusts rural women in Africa to nurture society (Acholonu, 1995); and
3) Nego-feminism and Snail-sense feminism, which both are lodged in feminism and womanism with tenets of gender inclusion, complementarity and collaboration (Nnaemeka, 2003; Ezeigbo, 2012).

These perspectives present the diverse cultural experiences of Africana women and the commonalities in the patriarchy, colonialism, neo-colonialism, modernization and globalization that lead to the racism and sexism they have encountered (Kolawole, 2004; Nkealah, 2006, 2016). Africana women's oppression cannot be separated from their racial identities and therefore, when conducting research, race is as important to assess as gender (Hudson-Weems, 1993; Joyce, 2001; Mollet and Faria, 2013).

Feminist political ecology includes a focus on intersectionality, the multiple systems of oppression on certain population groups ranging from racism, classism to sexism, in the assessment of gender dynamics of environmental resources and labor divisions (Rocheleau et al., 1996; Elmhirst, 2011; Mollet and Faria, 2013). In the Global South, Feminist political ecology scholars see women's gender roles as a source of oppression because of the feminization of poverty and marginalization (Jackson, 1996; Mollet and Faria, 2013). However, studies conducted about the Global South and presented as feminist political ecology rarely discuss race and ethnicity in explaining the inequalities that women face (Mollet and Faria, 2013). Some scholars believe that the focus on intersectionality has reduced the emphasis on the feminist part of Feminist political ecology leading to the limited studies labeled as feminist political ecology (Elmhirst, 2011). Other scholars contend that even with the importance that Rocheleau et al. (1996) gave to the intersection between gender, race, culture, and ecological change in feminist political ecology, the power of race is often absent or not assessed at the same level as gender in these studies (Mollet and Faria, 2013). Race is as critical of a variable as gender since the gender-nature-societal relationship not only depends on material needs and access to resources, but it is shaped by regimes of cultural meaning; how capitalism, patriarchy, and race/ethnicity shape women's subordination and oppression (Mollet and Faria, 2013). Some scholars contend that the lack of focus on race, ethnicity and caste systems in the field of political ecology is due to the international development's discourse that pins economic and cultural practices of the Global South as inadequate (Chakrabarty, 2000; Mollet and Faria, 2013). This does not leave out academia, as theoretical perspectives from the Global South are also often excluded in the analysis of research in Africana communities. If perspectives such as African feminism and Black feminism were included as prominent sub-fields of feminist political ecology research in Africana communities, it would provide different perspectives grounded in African traditions, customs and culture. The inclusion of these perspectives would also ensure that race, class and other systems of oppression and discrimination are put at the forefront of these studies. This is when Africana womanism could be used as an extension of feminist political ecology as there would be a rallying point where Africana womanism could link to.

In sum, Africana womanism, African feminism, and Black feminism, all relate back to the historical oppression of their racial identity, before they address the oppression they encounter through their gender identity. All three perspectives are constantly placing their feet in two or more realities –being black, being a woman, etc. (Few, 2007). Africana womanist scholars believe that the family comes first and that problems should be solved using a community-focused model. African feminists and Black feminists believe that because black women are the links to the survival of black families and communities, their needs must be addressed for everyone to reap the benefits. In essence, these three theoretical perspectives have the same goals, but different approaches. Although African feminism and Black feminism are rooted in African cultural perspectives, Hudson-Weems (1993) finds that feminism in itself is a westernized perspective that evolved in a racist paradigm and therefore, African feminism and Black feminism are working within a framework not defined by its own racial, historical underpinnings. Essentially, African feminism, Black feminism, and feminism can be seen as one of the same since solutions are developed by addressing sexism first even if racism is acknowledged. Nevertheless, the diverse perspectives of black women today should be considered when conducting political ecology and political ecology of Health research. This is critical as there are limited studies that include African theoretical perspectives in the analysis of political ecology and political ecology of health. Multiple perspectives such as Africana womanism and (African and Black) feminism will help provide a better understanding of the ways in which black women and men organize their thoughts, conduct their activities, and engage in their local and global communities. Using Africana womanism as an extension of feminist political ecology will enable researchers to better define, conduct and present research about gender dynamics in sub-Saharan Africa.

3.4. CONCLUSION

The protection of the environment and biodiversity is only possible when there is restored balance between gendered rights and responsibilities in societies and economies that provide justice to those societies. Political ecology and political ecology of health provide a different way to address concerns of communities around the world by ensuring that researchers consider the political and economic decisions that lead to environmental injustice and health inequalities. Feminism strengthens political ecology by addressing the gender imbalances in the costs and benefits of resource management, protection of distinct ecosystems, and the livelihoods that are dependent on the ecosystems. However, within an African context, feminism's westernized prescriptions may not be enough to address the real concerns of the population.

The Africana womanist perspective brings to the forefront an African perspective that acknowledges a family-centered rather than individualistic perspective. Women who prescribe to Africana womanism find that it may be best to avoid a westernized system that encourages individualism and destroys the notion of family and community. It is the same system that has shifted the outlook on the positive values of nurturing and emotionality as weak and rationality and individualism as strong; hence, the "inferiority" of women. Some scholars have noted that the eco-feminist perspective may engender what Africana womanists find to be missing in western notions of feminism. However, eco-feminism is still inadequate as it does not include men as victims of patriarchy; women are the only group perceived closer to nature and its proponents attempt to make eco-feminism a central perspective within feminism.

It is also important, however, to acknowledge that in today's reality, the negative legacy of colonialism in many Africana communities has created a "re-written" history, one that promotes the Enlightenment-era perception of women as "second-class citizens" because they are emotional beings and are responsible for household duties. Therefore, not only are traditional African customs being slowly erased, but they are also being replaced by Westernized notions of what a society and community should be. It is for that reason, that when conducting political ecology and political ecology of health research, it may not be suitable to use feminism or Africana womanism separately, but rather use Africana womanism as an extension of feminism. This link is even more plausible if African feminism and Black feminism are incorporated in the framework. This form of collaboration will avoid the essentialism that is occasionally observed when espousing one type of ideology. It is with this connection that gender dynamics will be better understood and will allow men and women to support one another to reach a society's full potential.

CHAPTER 4

"FLOODING OIL": ECO-SYNDEMICS AND CANCER RISKS IN WOMEN AND CHILDREN TO TOXIC POLLUTION AND SEVERE FLOODING IN DELTA STATE, NIGERIA

ABSTRACT

The Niger Delta region of Nigeria has dealt with decades of pollution from oil spills and gas flares due to the oil and gas industry's activities. This region is also known for its recurring floods and in recent years, floods have intensified due to poorly planned infrastructural development and climate variability. These floods have led to extensive damage of homes and livelihoods. However, the health implications of the compounded effects of excessive flooding and the oil industry have not been investigated in depth in the Niger Delta. There is the possibility of natural-technological (NaTech) events, which are natural disasters that damage industrial facilities resulting in the release of toxic chemicals into the environment. Furthermore, the multiple vulnerabilities such as poverty, oppression and exposure to oil pollution that the Niger Delta population endures may induce eco-syndemics, a phenomenon that recognizes the multi-factorial interactions that create environments that contribute to disease. This study was conducted as an initial investigation to determine whether an oil-producing community (Uzere) has worse health concerns and outcomes compared to a non-oil producing community (Aviara). Both communities are in flood-prone areas in Delta State in the Niger Delta. Atmospheric dispersion models are used to delineate five toxic chemicals emitted from a gas flare in Uzere. Group surveys of self-reported symptoms and health conditions of 208 women and their children living in both communities were conducted and analyzed. The results show that Uzere has greater levels of airborne pollution than Aviara. Furthermore, women and children in Uzere have greater levels of reported symptoms and health conditions compared to women and children in Aviara. This study provides an initial

assessment into the multiple vulnerabilities of oil-producing communities in the Niger Delta and the presence of eco-syndemics that will help inform future environmental health studies in the region.

4.1. INTRODUCTION

The oil and gas industry in the Niger Delta region of Nigeria has had significant impacts on the environment, economy and health of populations living close to their facilities. For decades, the Niger Delta region has been exploited for its extensive oil and gas deposits that account for 95.0 percent of the Nigerian government's export earnings, and 75.0 percent of the federal budgetary revenue (World Bank, 2013). While oil production has led to national economic prosperity, regional infrastructural development has largely been ignored resulting in disrupted livelihoods, high unemployment, poverty, conflict and public health risks from exposures to oil and gas pollution—oil spills and pollutants released from gas flares (Watts, 1999, 2005; Ibeanu, 2000; Ikelegbe, 2001; Adeola, 2001; Douglas et al., 2005; United Nations Development Program [UNDP], 2006; Ana et al., 2009; Gobo et al., 2009; United Nations Environmental Program [UNEP], 2011). Some scholars point to the political ecology of health to help explain the political and economic decisions that Western-dominated institutions impose in developing countries that create unequal power relations and lead to environmental degradation, the oppression and marginalization of the certain population groups, and health inequalities (Walker and Bulkeley, 2006; Singer, 2009; King, 2010; Jackson and Neely, 2014).

In addition to these factors, the Niger Delta is also experiencing more intense flooding in recent years. In 2012, Nigeria experienced severe riverine flooding from the Benue and Niger Rivers destroying homes and displacing thousands of residents in the region (Federal Government of Nigeria et al. 2013; Agada and Nirupama, 2015; Amangabara and Obenade, 2015). However, it is unknown whether Niger Delta communities close to oil and gas industry operations are experiencing natural-technological (NaTech) events, which are natural hazards (flooding) that trigger technological disasters leading to the release of hazardous substances from damaged industrial facilities (Arellano et al., 2003; Young et al., 2004; Cruz et al., 2006; Ruckart et al., 2008; Cruz and Krausmann, 2009; Sengul et al., 2012; Cruz and Krausmann, 2013). The Niger Delta is a prime example of how anthropogenic (oil and gas industry activities) and natural environmental damage (flooding) increases the vulnerability and susceptibility of residents, potentially resulting in poorer health and wellbeing. The phenomenon by which an array of infectious and chronic diseases emerge due to multi-factorial causes in marginalized communities without adequate health care is referred to as a syndemic (Singer and Clair, 2003; Baer and Singer, 2009; Singer, 2013a; Mendenhall et al., 2015). Empirical studies that have investigated syndemics have typically focused on specific illnesses and how traumatic social and/or financial distress or exposure to a source of infection exacerbate poor health. However, there are limited empirical studies investigating the cumulative health effects of exposure to anthropogenic and natural environmental damage; events that may comprise eco-syndemics, which are disease interactions caused by climate variability or other human-induced environmental consequences that increase the total burden of disease, particularly in historically marginalized and poor communities (Baer and Singer, 2009; Singer, 2013b).

This chapter addresses the gap in the literature on NaTech events and eco-syndemics by examining whether a flood-prone, oil-producing community (Uzere) has greater health concerns, compared to a flood-prone, non-oil producing community (Aviara) both located in the Isoko South Local Government Area in Delta State. Airborne chemical pollutants from one Uzere gas flare is estimated to assess the magnitude and extent of potential toxic exposures. A survey of women in Uzere and Aviara was also conducted to learn more about their health and the health of their children to determine the magnitude and extent of an eco-syndemic and ultimately the overall status of these communities' health.

This chapter begins with an overview of flooding and the potential health consequences of the oil and gas industry in the Niger Delta. It is followed with (a) an assessment of the concentrations and extent of five toxic chemicals released by gas flares in Uzere using a dispersion-based model and (b) a report of women and children's symptoms, health conditions and diseases obtained from group surveys conducted in November 2016 in Uzere and Aviara communities. A discussion about the potential cancer risks, other health consequences and potential eco-syndemics in Uzere is provided. Finally, we conclude that in the time of climate variability, specific attention must be given to oil-producing communities in flood-prone areas as these populations are potentially exposed to NaTech events and cumulative health hazards.

4.2. FLOODING IN THE NIGER DELTA

Rainfall has decreased overall in Nigeria; however, the coastal region of the Niger Delta has experienced slight increases (Adefolalu, 1986; Odjugo, 2005; Akinsanola and Ogunjobi, 2014) of approximately 2,900 millimeters (mm) of annual rain in more recent years (Odjugo, 2005). The rainy season in the Niger Delta is from April to October and while some research has found that the duration of rainy days has decreased (22.0 percent), there has also been a 38.0 percent increase in the number of rainstorms (Odjugo, 2005), which has increased the risk of flooding (Umoh, 2002; Ogundebi, 2004; Odjugo, 2005). Residents have in the past been able to mitigate flood risks with traditional mechanisms, but their vulnerability has increased following localized and recurring flood disasters (Ogri, 2001; Cruz and Krausmann, 2013; UNISDR, 2018), degradation of the fragile deltaic ecosystem from the oil industry (Akinro et al., 2008; Eregha and Irughe, 2009), poor infrastructural development in the region and other countries (Federal Government of Nigeria et al., 2013; UNISDR, 2018), and a lack of new adaptation resources (Federal Government of Nigeria et al., 2013; Amangabara and Obenade, 2015).

In 2012, the Lagdo Dam on the Benue River in the neighboring country of Cameroon failed due to excessive rainfall leading to an intensive disaster with flash floods overflowing the Benue and Niger Rivers in Nigeria (Federal Government of Nigeria et al., 2013; Agada and Nirupama, 2015; Amangabara and Obenade, 2015). Although the Nigerian Meteorological Agency (NIMET) had warned communities of the potential of massive flooding, this flood had the third highest number of people affected (approximately 7 million people) and the third highest number of deaths (363) worldwide from natural disasters (Guha-Sapir and Hoyois, 2013). People affected fled as their homes and businesses were submerged, refuse was displaced from dumpsites and sewage contaminated drinking water sources (Federal Government of Nigeria et al., 2013; Agada and Nirupama, 2015).

Delta state, the place of this study was particularly vulnerable due to its large number of rivers and riverine communities (Amangabara and Obenade, 2015). The Delta State Government declared a state of emergency and many residents were internally displaced (Leadership Initiative for Transformation and Empowerment [LITE-Africa], 2012). A multi-sectoral rapid needs assessment was carried out between October 19th and 21st 2012 by a team of development experts from the United Nations, Oxfam/LITE-Africa, and other non-governmental agencies (LITE-Africa, 2012). The assessment found that the severe flood exacerbated dire situations as most rural communities were highly dependent on subsistence farming and fishing for their livelihoods. Infrastructure such as buildings, water and electricity infrastructure, roads and other public assets in the Niger Delta, which were already in poor condition, were even more damaged because of the severity of the flood (LITE-Africa, 2012; Federal Government of Nigeria et al., 2013).

Previous research has shown that the impact phase of a flood, especially flash floods tend to be the most fatal with deaths as a result of drowning and traumatic injuries (Jonkman and

Kelman, 2005; Clements and Casani, 2016). During the post-flood phase, infectious diseases emerge including, waterborne gastrointestinal diseases (diarrhea and cholera), respiratory diseases (asthma), vector-borne diseases (malaria) and rashes/dermatitis are quite common (Woodruff et al., 1990; Kondo et al., 2002; Ahern et al., 2005; Lignon, 2006; Baer and Singer, 2009; Clements and Casani, 2016). Furthermore, with the oil and gas industry activities in the region, there is the possibility of a NaTech event. Regrettably, the oil and gas industry operating in the Niger Delta have not been transparent when damage from flooding occurs in their facilities and therefore, the additive health risks in these communities are difficult to measure and remain largely unknown (Federal Government of Nigeria et al., 2013; Cruz and Krausmann, 2013). In industrialized nations, NaTech events have led to oil spills and the release of air toxins resulting in an increase of respiratory illnesses and emotional stress (Schmidt, 2000; Young et al., 2004). However, these poor health outcomes can be even more compounded in regions such as the Niger Delta not only due to toxic releases during natural disasters, but communities near oil and gas operations are consistently exposed to oil spills and gas flaring. Therefore, it is expected that recurring floods and future flash floods will increase the prevalence of health conditions and diseases in communities exposed to oil production and potential NaTech events—a focus of this chapter.

4.3. OIL INDUSTRY and MATERNAL and CHILD HEALTH CONSEQUENCES

The exploitation of oil and gas in the Niger Delta has degraded the environment, contaminated soils and rivers, and polluted the air that residents breathe, forcing many agricultural and fishing communities into poverty and conflicts with the Federal Government of Nigeria and Multinational Oil Companies (Adeola, 2000, 2001; Ibeanu, 2000; Ogri, 2001; UNDP, 2006; Ikporukpo, 2007; Bassey, 2008; Environmental Rights Action [ERA], 2008; Anyakora et al., 2008; Ana et al., 2009; UNEP, 2011; Ismail and Umukoro, 2012; Olawoyin et al., 2012). Although the oil industry is not the only polluting industry in the region, numerous studies have shown that oil and gas extraction activities have had widespread and detrimental impacts on the environment and health of the population (Adeola, 2000, 2001; Ibeanu, 2000; Ogri, 2001; UNDP, 2006; Bassey, 2008; ERA, 2008; Anyakora et al., 2008; Ana et al., 2009; UNEP, 2011; Ismail and Umukoro, 2012; Olawoyin et al., 2012). The most detrimental to both the environment and human health are toxic chemicals released from oil spills and gas flare-byproducts. The amount of oil spillage in the Niger Delta is catastrophic with recent studies showing approximately 13 million barrels (1.5 million tons) of oil spilled since 1958 (Ordinioha and Brisbe, 2013). In Uzere community in Delta state, one of the study communities, three oil spills were reported to the Nigerian Oil Spill Detection and Response Agency (NOSDRA) since 2014 (NOSDRA, 2018).

Gas flaring is associated gas released during oil production, which is piped and then burned in an open flame into the environment as waste or unusable gas. As of 2015, there were approximately 174 gas flare sites in the Niger Delta (National Oceanic and Atmospheric Administration [NOAA] et al., 2016). These flares comprise various toxic chemicals such as particulate matter (PM_{10}, $PM_{2.5}$ and PM aerosols), sulfur dioxide, nitrogen dioxide, benz[a]pyrene, dioxin, benzene, toluene, styrene, xylenes, and ethyl-benzene (Oluwole et al., 1996; Argo, 2001; ERA, 2008; Gobo et al., 2009; Ismail and Umukoro, 2012), some of which are carcinogenic and teratogenic. A study conducted by Oluwole et al. (1996) in oil-producing communities in the Niger Delta found that volatile carbon oxides, nitrogen oxides, sulfur oxides, carbon monoxide and PM exceeded the Nigerian Federal Environmental Protection Agency's 1991 standards because of gas flare emissions. Abdulkareem (2005) conducted a study on the ground level concentrations of carbon dioxide, sulfur dioxide, nitrogen dioxide, and total hydrocarbons in the Niger Delta and found that effects of these concentrations were felt within 1,000 meters (m) radius from the flare station with the first 200m to 600m radius as the most dangerous. However, limited studies have been conducted on aromatic hydrocarbons released during gas flaring such as benzene, toluene, xylenes, styrene and ethyl-benzene even though some are known to be carcinogenic.

4.3.1. Cancer Risks

Cancer is considered the "silent killer" in Africa. Cancer rates are lower in African countries, which has led to less of a focus and financial resources to combat cancer. The lower rates can be partially linked to the lack of data available about cancer diagnoses in Africa (Stefan, 2015). Also, most of the continued focus of health programs is on infectious diseases such as HIV, tuberculosis and malaria. Unlike higher income nations, people diagnosed with cancer in African countries tend to have lower survival rates (Stefan, 2015). For instance, Youlden et al. (2012) found that women with breast cancer have a 5-year survival rate of 82.0 percent in Europe while it ranges between 12.0 to 46.0 percent in some African countries. Therefore, more resources have to be put in place to reduce the root causes of these cancers and increase treatments.

According to the United States Department of Health and Human Services (2003), two-thirds of all cancer diagnoses are from environmental causes and it normally takes 20 to 30 years for individuals to develop symptoms after exposure. Some experts and scholars in Nigeria have raised the alarm of a potential epidemic of cancer in the Niger Delta by 2025 due the population's exposure to these and other toxins in the air, water, and food that are known to be environmental carcinogens and genotoxic (Anyakora et al., 2008) with children at greater risk (Olawoyin et al., 2012). Dr. Chimezie Anyakora, an expert in crude oil pollutants in Nigeria, has found that the increasing spillage of oil from mechanical failure as well as illegal bunkering of oil is one of the main reasons for a potential epidemic of cancer (Nigeria NewsDay, 2016). Niger

Delta communities, particularly those located near the oil industry, are exposed on a daily basis to industrial pollutants and are therefore, at heightened risks of exposure to cancer-causing chemicals. Between December 1997 and December 2000, 362 cases of cancer were reported at the University of Port Harcourt Teaching Hospital in Rivers state (Georgewill, 2012). While the underlying population at risk is not reported, the number of newly reported cases over a three-year period is significant and therefore, it is important to determine whether certain population groups are at increased risk.

4.3.2. Maternal and Child Health

The health of women and children in a community characterizes the status of community health (Reidpath and Allotey, 2003). Women, particularly in rural communities are generally engaged in subsistence farming and fishing in the Niger Delta (Nigerian Ministry of the Environment, 2014; interviews with Uzere and Aviara Representatives, 2014) increasing their risk of exposure to oil and gaseous chemical-byproducts from the oil industry. Children are also more susceptible to infection and diseases than adults because they are still developing physiologically and therefore, tend to be more susceptible to the untoward effects of environmental pollutants (Sly and Flack, 2008). Empirical studies on the impacts of oil pollution on maternal and child health in the Niger Delta are limited. However, a number of scholars in recent years have examined these adverse health outcomes.

Bruederle and Hodler (2017) found that infants born within 10 km of an oil spill that occurred during the mother's pregnancy, doubled the risk of neonatal mortality (Bruederle and Hodler, 2017). These authors further estimated that 70.0 percent of the 16,000 neonatal infants (first month of life) that died in 2012 would have survived if the mother had not lived close to an oil spill (Bruederle and Hodler, 2017). A cross-sectional study conducted by Abbey et al. (2017)

found that infants born at the University of Port Harcourt Teaching Hospital in Rivers state exhibited similar prevalence rates of major congenital abnormalities as infants born in European hospitals (20.7 per 1,000 live births vs. 20.3). This study also found that infants born with congenital abnormalities in Rivers state presented with higher than expected rates of nervous system abnormalities compared to other states outside of the Niger Delta, possibly attributed to prenatal oil and gaseous chemical-byproduct exposures (Abbey et al., 2017). Children in the Niger Delta are also more susceptible to poor neurological development when exposed to PM that contain high levels of lead (Ndubuisi and Asia, 2007). Finally, Georgewill's (2012) animal study and other human studies (UNDP, 2006; Nkwocha et al. 2008; Ana et al., 2009; Gobo et al., 2009; UNEP, 2011; Ismail and Umukoro, 2012) on oil exposure and its health impacts found symptoms of weight loss, loss of appetite, weakness, secondary infertility, frequent miscarriages and premature death in women further justifying the need to understand the health impacts of oil spills and gas flare exposure among residents in the Niger Delta.

4.4. PURPOSE OF THE STUDY

The purpose of this study is to determine whether an oil producing community has worse health concerns than a non-oil producing community when both are located in flood-prone zones. The study has two objectives: (a) to conduct an environmental assessment in Uzere community to estimate the magnitude and extent of airborne chemical pollutants known to cause adverse health effects, emitted from gas flares during oil extraction; and (b) to investigate the health concerns and conditions in women and children in Uzere (oil producing community) compared to Aviara (a non-oil producing community). Since Uzere and Aviara are both in flood-prone zones, it will be assumed that differences in adverse health outcomes will be attributed to cumulative chemical exposures.

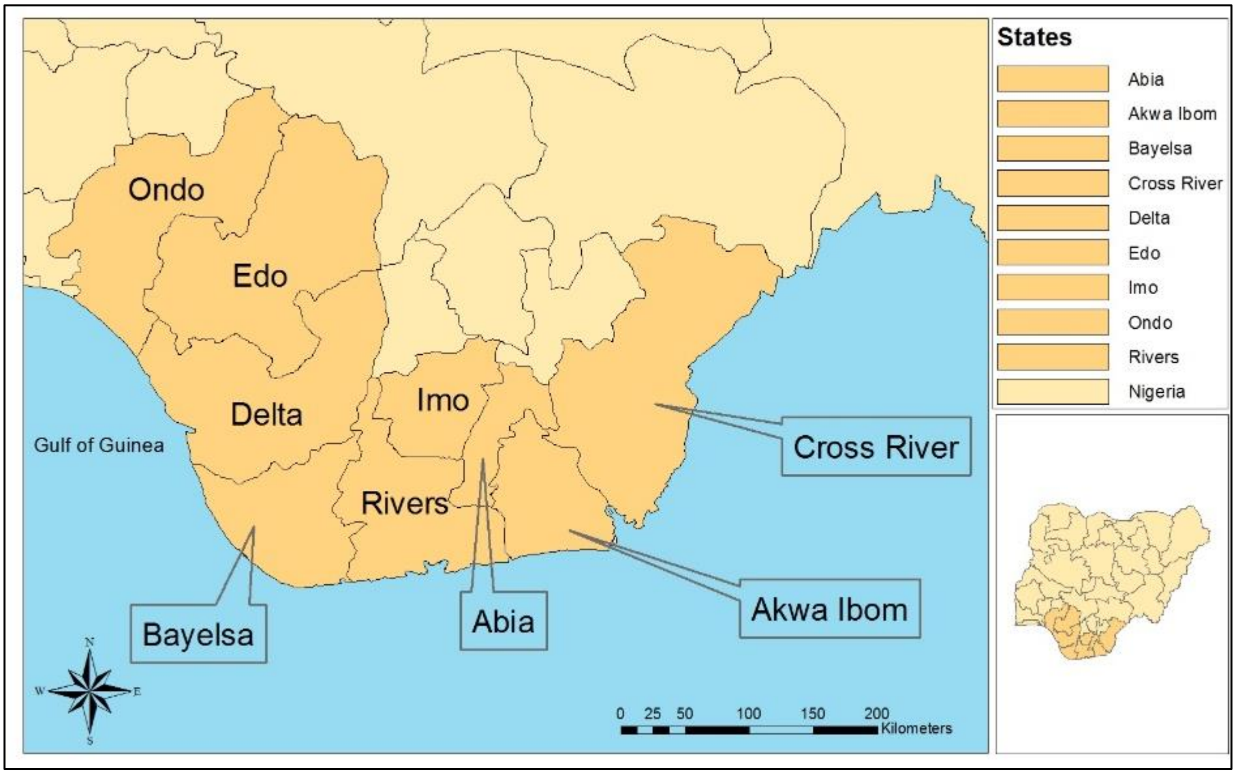
The second objective in this study incorporated community-based participatory research (CBPR) methods to ensure the inclusion of communities in research development and analysis of results (Wallerstein and Durhan, 2006; Chevalier and Buckles, 2013; Hacker, 2013; Casale et al., 2013; Musesengwa and Chombari, 2017). This type of research ensures that the methods used are culturally appropriate. Communities often feel exploited by researchers since research was historically conducted "for them rather than with them" (Chevalier and Buckles, 2013; Hacker, 2013). CBPR addresses some of the ethical concerns that arise when conducting research in regions or with populations that have been exploited (Musesengwa and Chombari, 2017). These ethical concerns have included the release of sensitive data without community approval and lack of feedback after the research has been completed (Musesengwa and Chombari, 2017). The CBPR method also allows equal participation of the researcher and community and ensures direct benefits are provided to the communities (Hacker, 2013; Casale et al., 2013). Researchers also must be willing and ready to accept that during the implementation of CBPRs, it is necessary to adapt to the needs and wants of the community (Casale et al., 2013; Musesengwa and Chombari, 2017). Therefore, this research study used the Africana womanism theoretical perspective as an extension of feminism (refer to Chapter 3 for more information) to guide the survey design, implementation, and analyses to ensure a more contextual and representative study. The feminist perspective does not adequately address Africana women's experiences and needs and Africana womanism, as an alternative, is a family-centered perspective that specifies that women's needs are only accounted for once the needs of the family/community as a whole have been addressed (Hudson-Weems, 1993; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008; Pellerin, 2012).

4.5. DATA and METHODS

4.5.1. Study Communities

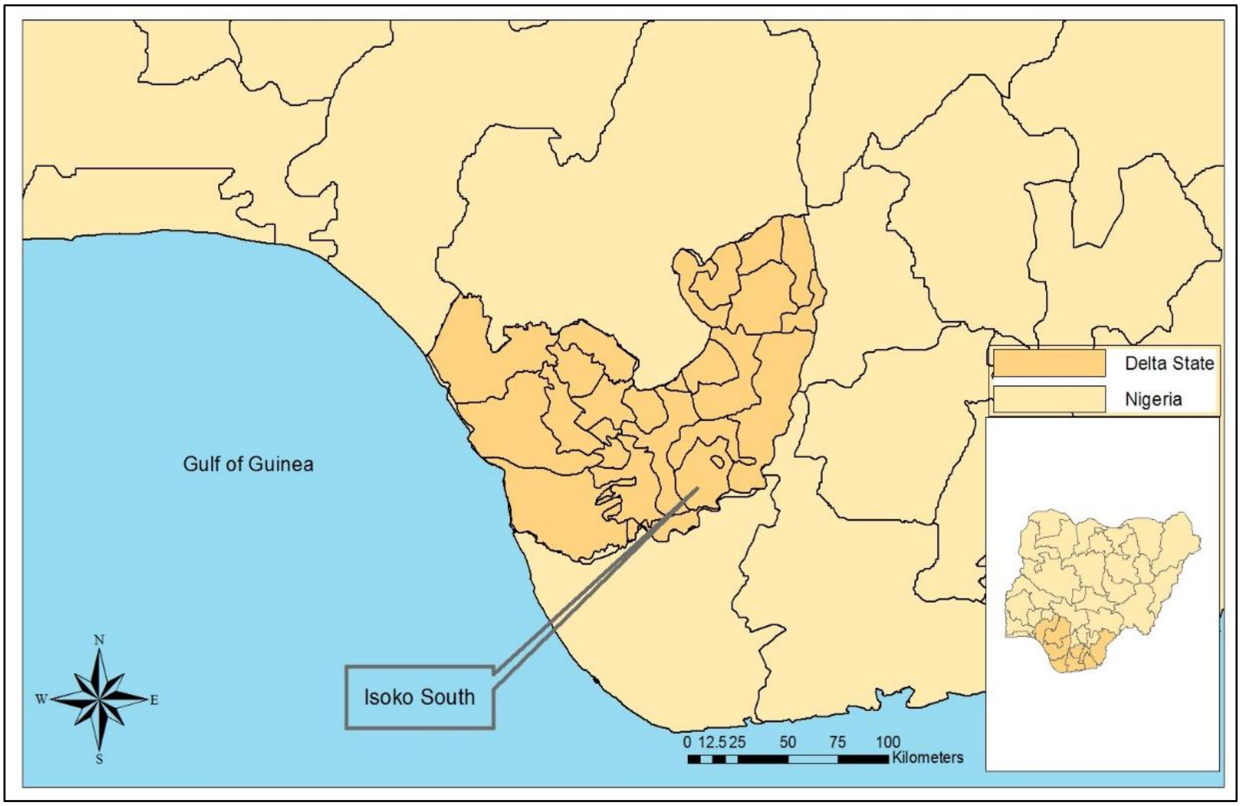
The Niger Delta is located on the coast of the Gulf of Guinea between 40° to 60° N latitude and 50° to 80° E longitude in Nigeria. It has a tropical climate and is known as one of the largest and most vital wetlands in the world, comprising approximately 75,000 km^2. There are three administrative levels in Nigeria and the Niger Delta: national, states, and local government areas (LGAs). This study is conducted in Delta state (Figure 4-1) with a population of 4,112,445 comprising 890,312 households (average members per household = 3.5 in urban and 7.0 in rural communities) (National Bureau of Statistics and the World Bank, 2013). In 2004, Delta state had the highest incidence of poverty (45.4) in the Niger Delta (Oviasuyi and Uwadiae, 2010). Uzere and Aviara communities are located in Isoko South LGA in Delta state (Figure 4-2) and were chosen for this study because Uzere is oil producing and Aviara is non-oil producing, but both communities had similar cultural and socio-demographic profiles. Uzere had an estimated population of 40,535 (Oak Ridge National Laboratory [ORNL, 2016), an area of 9.64 km^2 (Google Maps, 2018a) and population density, 4,204 people per km^2. Aviara had a smaller population of 12,640 (ORNL, 2016), an area of 3.35 km^2 (Google Maps, 2018b) but relatively similar population density, 3,773 people per km^2.

Figure 4-1: Map of the Niger Delta region of Nigeria.



Source: United Nations Office for the Coordination of Humanitarian Affairs in Nigeria (OCHA Nigeria), 2017. Map created by Fatoumata B. Barry (2017).

Figure 4-2: Map of Isoko South in Delta state, Nigeria.



Source: United Nations Office for the Coordination of Humanitarian Affairs in Nigeria (OCHA Nigeria), 2017. Map created by Fatoumata B. Barry (2017).

4.5.2. Data

4.5.2.1. Environmental Data

Various sources were used to obtain data on gas flares in the Niger Delta. The geographic coordinates of the gas flares were obtained from NOAA National Centers for Environmental Information, NOAA Joint Polar Satellite System (JPSS) Proving Ground Program and the World Bank Global Gas Flaring Reduction Partnership (GGFR) (2016). Gas flare stack height and diameter were provided during a site visit at the Uzere oil facility in November 2016. Heat released from gas flares in the Niger Delta were obtained from Abdulhakeem and Chinevu's (2015) paper on the impacts and remedies of gas flaring in Nigeria. The chemical composition, chemical concentration, emission rates, and stack gas exit (flow rate) were provided by Argo's (2001) report on the effects of potential oil and gas exploration and drilling activities in Canada. Data specific to Nigerian gas flares are not made public and therefore, using Argo's (2001) report provided data on the chemicals released from gas flares in sweet crude oil production, also commonly found in the Niger Delta. Sweet crude oil is a higher quality oil that has less impurities (< 1.0 percent of sulfur), which reduces cost and time for processing (Hyne, 2012). In addition, ambient air temperatures, meteorology, simple terrain (rural areas) and distances were provided by SCREEN View 4 software (Lakes Environmental Software, 2016) used for the modeling of emissions in this study. The imagery upon which the gas flares were positioned was obtained from the ArcGIS World Imagery Basemap (Environmental Systems Research Institute [ESRI] et al., 2018). The administrative boundaries for use in ArcGIS were provided by the United Nations' Office for the Coordination of Humanitarian Affairs in Nigeria (UNOCHA-Nigeria, 2015). Boundary coordinates for Uzere and Aviara were obtained from Google Maps (2018a, 2018b). Finally, to assess gas flares in relation to potential flooding, flood zones for the Niger Delta were provided by UNOCHA-Nigeria (2015) and NASA (2012).

4.5.2.2. Health Data

Group surveys of 208 women living in Uzere (100) and Aviara (108) were conducted for two days in each community in November 2016. There were four group survey sessions in each community. Group surveys were conducted rather than household surveys because the community leaders preferred a group-oriented research study and the pre-test in 2015 showed that women were more participatory in a group setting compared to interviews at home. Both Uzere and Aviara communities are inhabited primarily by Isoko people, a minority and marginalized group in the Niger Delta region. Both communities are in a similar flood-prone zone and have similar levels of socioeconomic status (engaged in subsistence farming and fishing); reducing the potential of confounding in the statistical models. Approval to conduct this study was provided by the paramount rulers of Uzere and Aviara Kingdoms in August 2014. A town hall meeting took place in each community in October 2016 to inform all residents of the impending group surveys for women over 18 years of age, to be held during market days in November 2016. Market days are when women are not working on the farms and go into the market to either purchase or sell produce. Banners of the group survey sessions were placed in the marketplace and reminders were included in women group meetings that took place in October and November 2016, in the respective community centers. Group survey participants were selected systematically using a stratified sampling strategy in order to obtain a sample that was representative of Uzere and Aviara women between the ages of 18 to 80. Although in many research studies, women of reproductive age are normally the only strata chosen, this study was also seeking to investigate the signs, symptoms and health conditions and concerns of women who lived in these communities for most or all of their lives to understand the evolution of health issues. A systematic, stratified sampling strategy divided the population into smaller groups based on sex (females) and systematic sampling, a random start on a list selecting every 'nth' person to participate, was used (Creswell, 2014). In this study, women in both communities were asked to form a line outside of the community center and every second women in the line was asked to participate in the group survey.

The group survey consisted of 56 questions in four categories: women's health, pregnant women's health, child health, and socio-economic status (Appendix A). The group surveys were structured with closed and open-ended questions that addressed two main topical areas: (a) self-reported symptoms and health conditions and diseases of the women and their children (if any); and (b) the demographics/socio-economic status of the women surveyed. Questions about pregnancy health and children's health were asked only to women who gave birth to a child that was at the time at least 12 years of age or younger or women who had children in their household who were 12 years of age or younger. Although most studies focus on the health of children under the age of 5 years, after discussion with civil society groups and community representatives, community members from both communities found that their children were healthier after the age of 10-12 years. Therefore, in order to be inclusive of the communities wishes, we considered the health of children from the age of 12 years and younger. If a woman did not fit into these two groups, they were asked to refrain from answering questions in the pregnant women's and child's health categories.

The survey was written in English and in a pre-group survey implementation meeting, it was translated to pidgin English to ensure that the meanings of the questions were properly conveyed. During the implementation of the group surveys, a community volunteer was present to translate from pidgin English to Isoko for any participant who did not understand pidgin English. The group surveys were conducted by two trained, English and pidgin English enumerators. Group survey participants received an incentive of the equivalent of five dollars in naira (Nigerian currency). Women who came to the session and were not chosen to participate received the equivalent of one dollar in naira as gratitude. All participants verbally consented to participate. Approval was obtained from the Institutional Review Board (IRB) at Michigan State University (IRB# x13-337e) to conduct pre-study semi-structured interviews in May–June 2013 (n=23), July–August 2014 (n=10) and survey pre-tests (n=6) in October 2015, in addition to the group surveys in November 2016 as mentioned above. Due to this study taking place in rural communities that have dealt with decades of neglect and conflict, it was important to implement this study with the assistance of staff at LITE-Africa in communities that they and the primary author of this study had built trust for a number of years. A validation meeting led by LITE-Africa took place in June

2017 in Uzere and Aviara, which included community residents, community leaders, and health professionals working in these communities (data not presented).

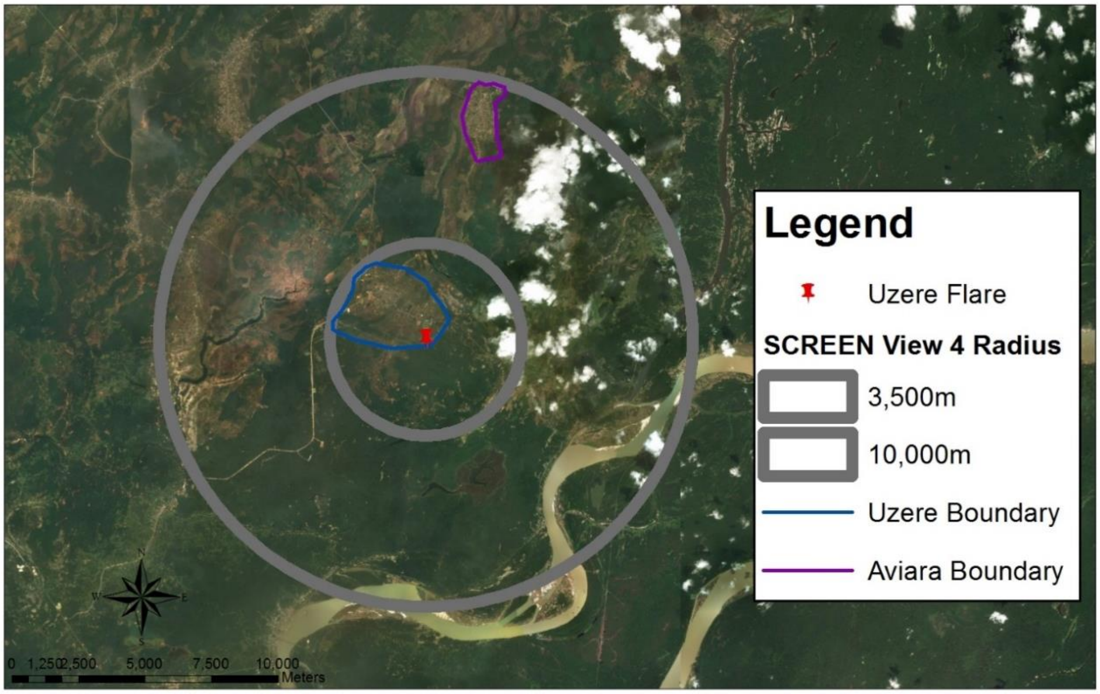
4.5.3. Data Analyses

4.5.3.1. Environmental Analysis

The State of California (Cal) and the United States Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limits (PELs) for workers and the Agency for Toxic Substances and Disease Registry's (ATSDR) Minimum Risk Levels (MRL) were used to determine health risks of chemicals released by one of the two gas flares in Uzere. Cal/OSHA's PELs were used in this study because OSHA's national guidelines are outdated; they date back to 1968. The United States Department of Labor (USDL) suggests using alternative occupational exposure limits such as Cal/OSHA's PELs that are as recent as 2016 (USDL, 2018). Cal/OSHA PELs have three major categories: total weighted average (TWA), which is the average of airborne exposure in any 8-hour work shift of a 40-hour week that should not be exceeded; short term exposure limits (STEL), which is the maximum exposure over a short period of time (15 minutes); and ceiling limits, which is the maximum exposure limit, which cannot be exceeded for any length of time (State of California/OSHA, 2016). This study used TWA to assess the chemicals. An MRL is defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of adverse effects (non-carcinogenic) over a specified duration of exposure – short (14 days or less), intermediate (15 to 364 days) and chronic (365 days or more) (ATSDR, 2007). MRLs are intended to serve as a screening tool to help public health professionals decide where to look more closely. Exposure to a level above the MRL does not mean that adverse health effects will occur. Chronic MRLs were used to assess the chemicals in this study since the Uzere gas flares have operated over 365 days.

There are a number of chemicals released by gas flares, but the five chemicals that pose the most serious health risks to humans were assessed: benzene, toluene, xylenes, styrene, and ethyl-benzene, some of which are known carcinogens. The SCREEN View 4 software, a dose-response model developed by Lakes Environmental, which is a user-friendly interface of SCREEN3, a United States Environmental Protection Agency (EPA) air dispersion model, was used to estimate the concentration (ppm/8-hour day; ppm/24-hour day) and the distance of the release of each chemical from the gas flare source. SCREEN View 4 allows users to estimate the extent and worst-case ground level concentrations of various pollutants dispersed by gas flares (Lakes Environmental Software, 2016). SCREEN View 4, as most risk assessment software, models the worst-case scenarios. This software was used to delineate the zones of greatest impact by the chemicals released from one of the two gas flares in Uzere immediately surrounding the gas flare to 10,000 meters (m). SCREEN View 4 modeled the chemicals up to 10,000m because that was the extent of the releases from the parameters provided (Figure 4-3). Aviara is located at the outer periphery of the 10,000m zone. The modeling parameters included a stack height of 2.44m, stack inside diameter of 0.45m, stack gas exit (flow rate) of 0.10 cubic meter per second (m^3/s), stack gas exit temperature of 1,273 kelvin (K), ambient temperature of 293K, full meteorology class (worse case meteorological conditions) and simple terrain (Table 4-1). Emission rates were different for each chemical evaluated: benzene (0.01165 grams per seconds [gm/sec]), toluene (0.00182 gm/sec), xylenes (0.00298 gm/sec), styrene (0.0075 gm/sec), and ethyl-benzene (0.00796 gm/sec). The modeled emissions from SCREEN View 4 were input into ArcGIS 10.5 (ESRI, 2017) to map the concentration and extent of individual chemicals released. There are two horizontal gas flares at the Uzere Oil Facility and according to one of the Uzere Oil Facility Employees, they are both used simultaneously. To facilitate a baseline, the data input into SCREEN View 4 assessed one gas flare, not both.

Figure 4-3: SCREEN View 4 Radius for Concentrations.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

Table 4-1: SCREEN View 4 Inputs for Assessment of Chemicals Released by One Uzere Gas Flare, Delta state.

Toxic Chemicals	Emission Rate (g/sec)*1	Stack Gas Exit – Flow Rate (m^3/s) *1	Stack Height (m) *2	Stack Inside Diameter (m) *2	Stack Gas Exit Temperature (K) *3	Ambient Air Temperature (K) *3
Benzene	0.01165	0.10	2.44	0.45	1,273.00	293
Toluene	0.00182	0.10	2.44	0.45	1,273.00	293
Xylenes	0.00298	0.10	2.44	0.45	1,273.00	293
Styrene	0.00755	0.10	2.44	0.45	1,273.00	293
Ethyl-Benzene	0.00796	0.10	2.44	0.45	1,273.00	293

*1 – Argo, 2001
*2 – Uzere Oil Facility Employee
*3 – SCREEN View 4 default settings

4.5.3.2. Health Analysis

The study design was a retrospective, cross-sectional comparison between two groups (Uzere=case and Aviara=control). This was an ecological study, since individual-level information on women and their children were not collected. Descriptive statistics and multi-variable logistic regressions were conducted in IBM SPSS Statistics 24.0 to estimate the unadjusted odds ratio (OR) and 95% confidence intervals (CI) of self-reported symptoms, health conditions, and diseases (or a combination of these outcomes) in women and their children, and socio-demographic characteristics in women in Uzere and Aviara. The sample and survey construction did not allow for adjustment in the above models. Two non-parametric tests (Pearson's Chi-Square and Fisher's Exact Test) were used to estimate the odds ratio and 95% confidence intervals. The Fisher's Exact Test is reported in the results. The odds ratios and 95% confidence intervals for statistically significant (p-value < 0.05) responses are reported in the results below.

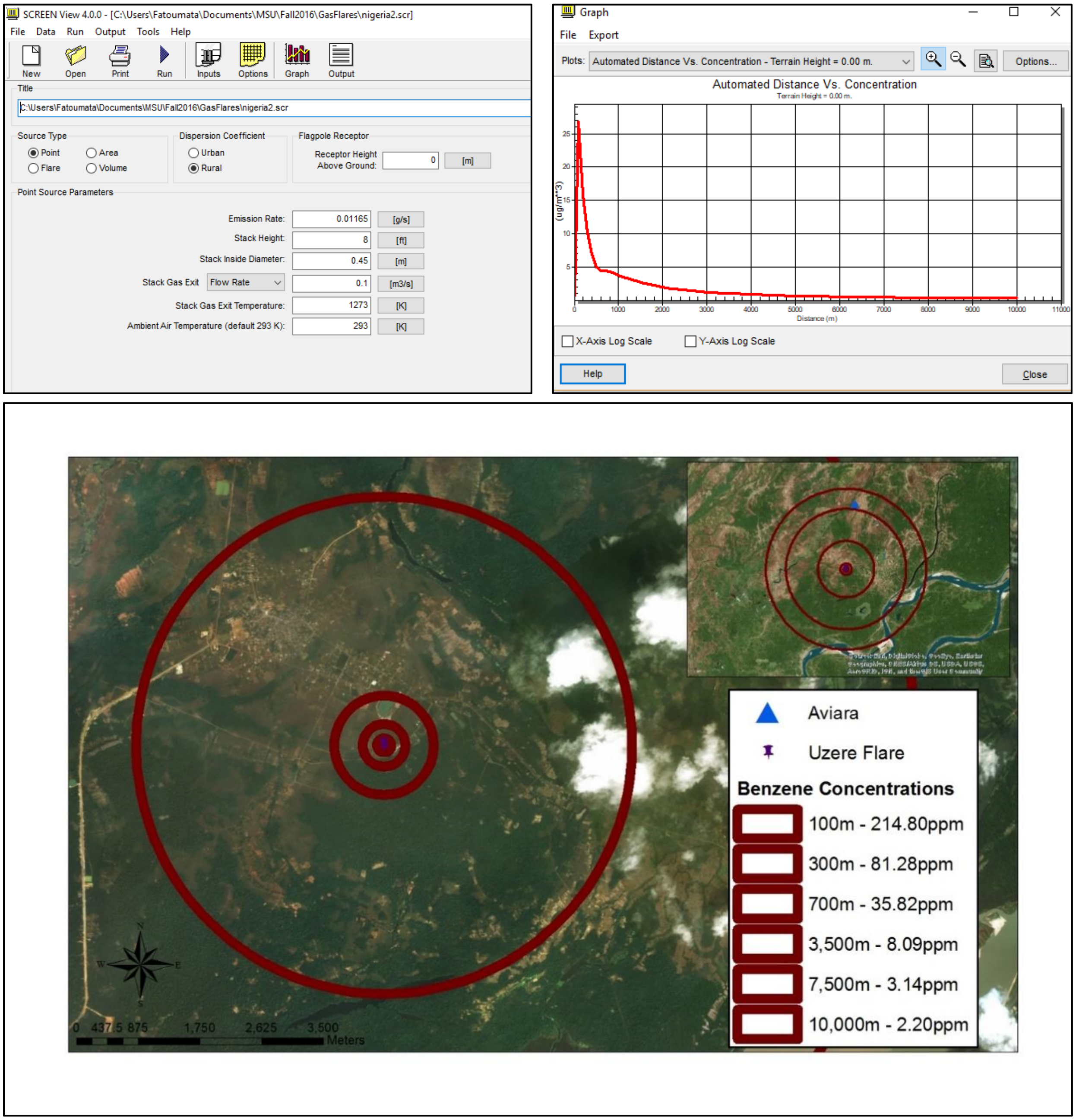
4.6. RESULTS

4.6.1. Environmental Assessment

All chemicals assessed in SCREEN View 4 were from one of the two gas flares in Uzere (Table B-1 and Table B-2) and were excessively above the ATSDR Chronic Minimal Risk Levels (MRL) at all distances up to 10,000m. The California/OSHA's Permissible Exposure Limits (Cal/OSHA's PELs) had different outputs for each chemical assessed. Benzene was above Cal/OSHA's PELs at all distances up to 10,000m. Toluene, styrene and ethyl-benzene were above Cal/OSHA's PELs at certain distances. Xylenes did not exceed Cal/OSHA's PEL. A detailed report of findings for each chemical is provided below. To review the detailed report of each chemical's magnitude at each distance, please refer to Table B-1 and Table B-2 in the Appendices section.

Benzene concentrations ranged from 26.85 ppm/hour immediately surrounding the gas flare to 0.27 ppm/hour at 10,000m from the flare (Figure 4-4 and Table B-1). Cal/OSHA's PEL for benzene is 1.0 ppm/8-hour day. Benzene substantially exceeded Cal/OSHA's PEL if the flare was operational for at least 8 hours a day; 214.80 ppm immediately surrounding the flare to 2.20 ppm at 10,000m from the flare. The ATSDR Chronic MRL for benzene is 0.003 ppm/24-hour day. Benzene was substantially above the ATSDR Chronic MRL if the flare was operational for 24 hours a day; 644.40 ppm immediately surrounding the flare to 6.60 ppm at 10,000m from the flare. In summary, benzene concentrations were excessively high in Uzere, but reduced quite substantially at the 10,000m perimeter, which encompassed Aviara community.

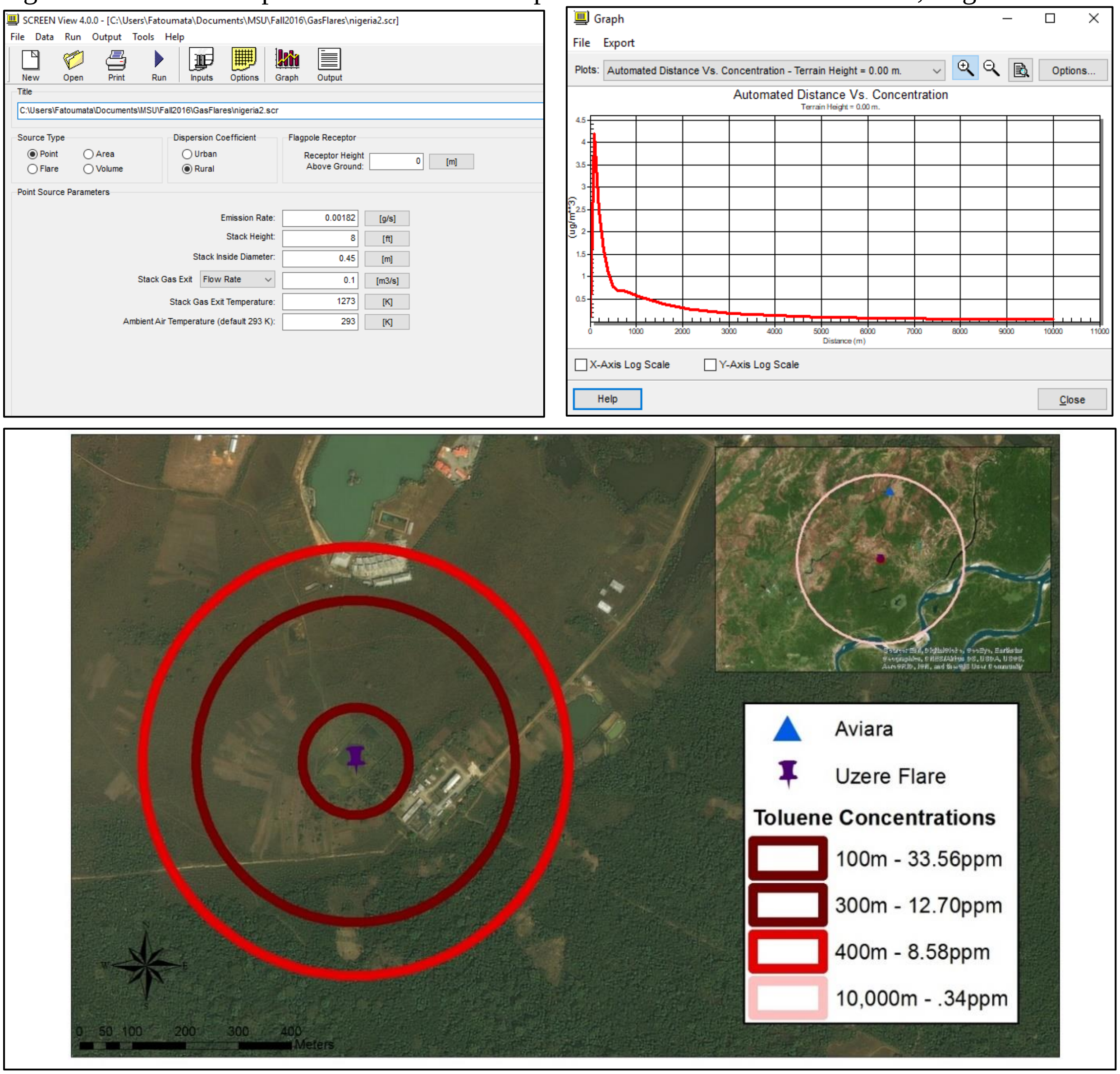
Figure 4-4: Benzene Input Parameters and Output Concentrations – Uzere Flare, Nigeria.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

Toluene concentrations ranged from 4.2 ppm/hour immediately surrounding the gas flare to 0.04 ppm/hour at 10,000m from the flare (Figure 4-5 and Table B-1). Cal/OSHA's PEL for toluene is 10.0 ppm/8-hour day. Toluene exceeded Cal/OSHA's PEL if the flare was operational for at least 8 hours a day; immediately surrounding the flare (33.56 ppm) to 300–400m from the flare (12.70–8.58 ppm). The ATSDR Chronic MRL for toluene is 1.0 ppm/24-hour day. Toluene was substantially above the ATSDR Chronic MRL if the flare was operational for 24 hours a day ranging from 100.68 ppm immediately surrounding the flare to 1.03 ppm at 10,000m from the flare. Thus, toluene concentrations were excessively high in Uzere for the ATSDR's chronic MRL but were only over Cal/OSHA's PEL immediately surrounding the flare to 300–400m. Toluene concentrations were reduced quite substantially at the 10,000m perimeter, which encompassed Aviara community.

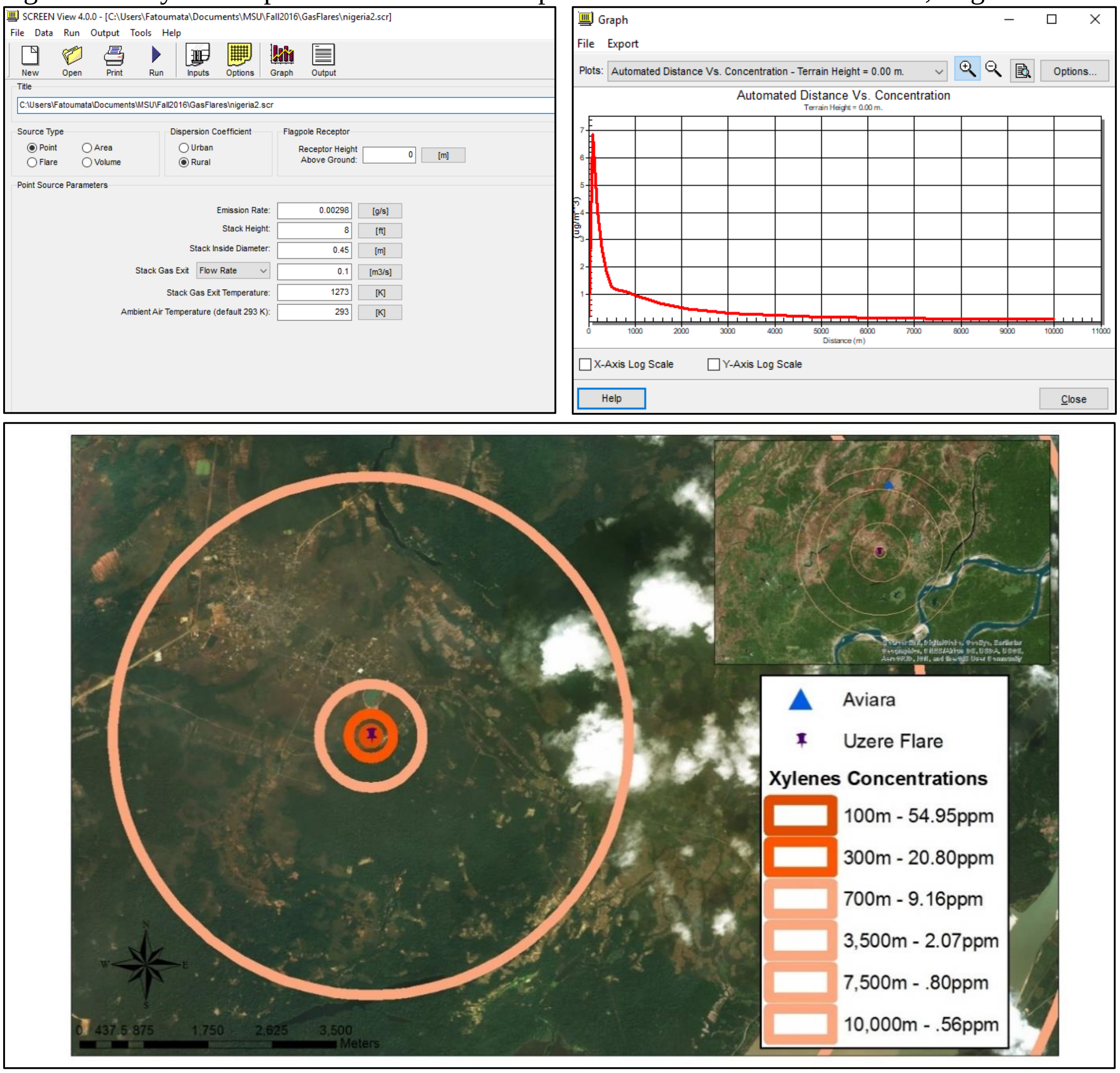
Figure 4-5: Toluene Input Parameters and Output Concentrations – Uzere Flare, Nigeria.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

Concentrations for xylenes ranged from 6.87 ppm/hour immediately surrounding the gas flare to 0.07 ppm/hour at 10,000m from the flare (Figure 4-6 and Table B-2). Cal/OSHA's PEL for xylenes is 100 ppm/8-hour day. Xylenes did not exceed Cal/OSHA's PEL if the flare was operational for at least 8 hours a day; 54.95 ppm immediately surrounding the flare and 0.56 ppm at 10,000m from the flare. The ATSDR Chronic MRL for xylenes is 0.05 ppm/24-hour day. Xylenes were substantially above the ATSDR Chronic MRL if the flare was operational for 24 hours a day ranging from 164.86 ppm immediately surrounding the flare to 1.69 ppm at 10,000m. Thus, concentrations of xylenes were excessively high in Uzere for the ATSDR Chronic MRL, but not for Cal/OSHA's PEL. Concentrations for xylenes were reduced quite substantially at the 10,000m perimeter, which encompassed Aviara community.

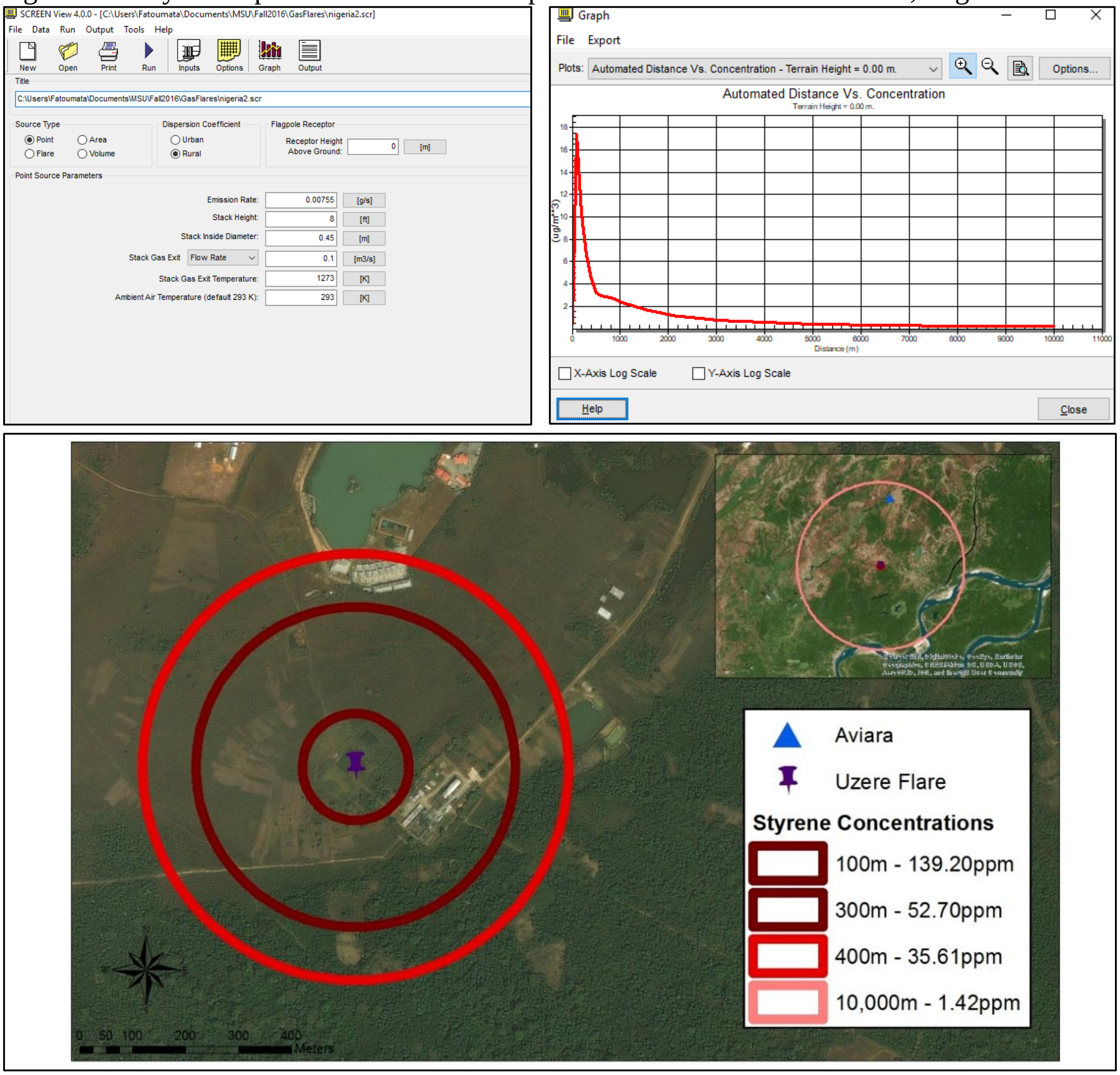
Figure 4-6: Xylenes Input Parameters and Output Concentrations – Uzere Flare, Nigeria.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

Styrene concentrations ranged from 17.4 ppm/hour immediately surrounding the gas flare to 0.02 ppm/hour at 10,000m from the flare (Figure 4-7 and Table B-2). Cal/OSHA's PEL for styrene is 50.0 ppm/8-hour day. Styrene exceeded Cal/OSHA's PEL if the flare was operational for at least 8 hours a day; immediately surrounding the flare (139.20 ppm) to 300–400m (52.70–35.61 ppm) from the flare. The ATSDR Chronic MRL for styrene is 0.20 ppm/24-hour day. Styrene was substantially above the ATSDR Chronic MRL if the flare was operational for 24 hours a day ranging from 417.60 ppm immediately surrounding the flare to 4.27 ppm at 10,000m. Thus, styrene concentrations were excessively high in Uzere for the ATSDR Chronic MRL but were only over Cal/OSHA's PEL immediately surrounding the flare to approximately 400m. Styrene concentrations reduced quite substantially at the 10,000m perimeter, which encompassed Aviara community.

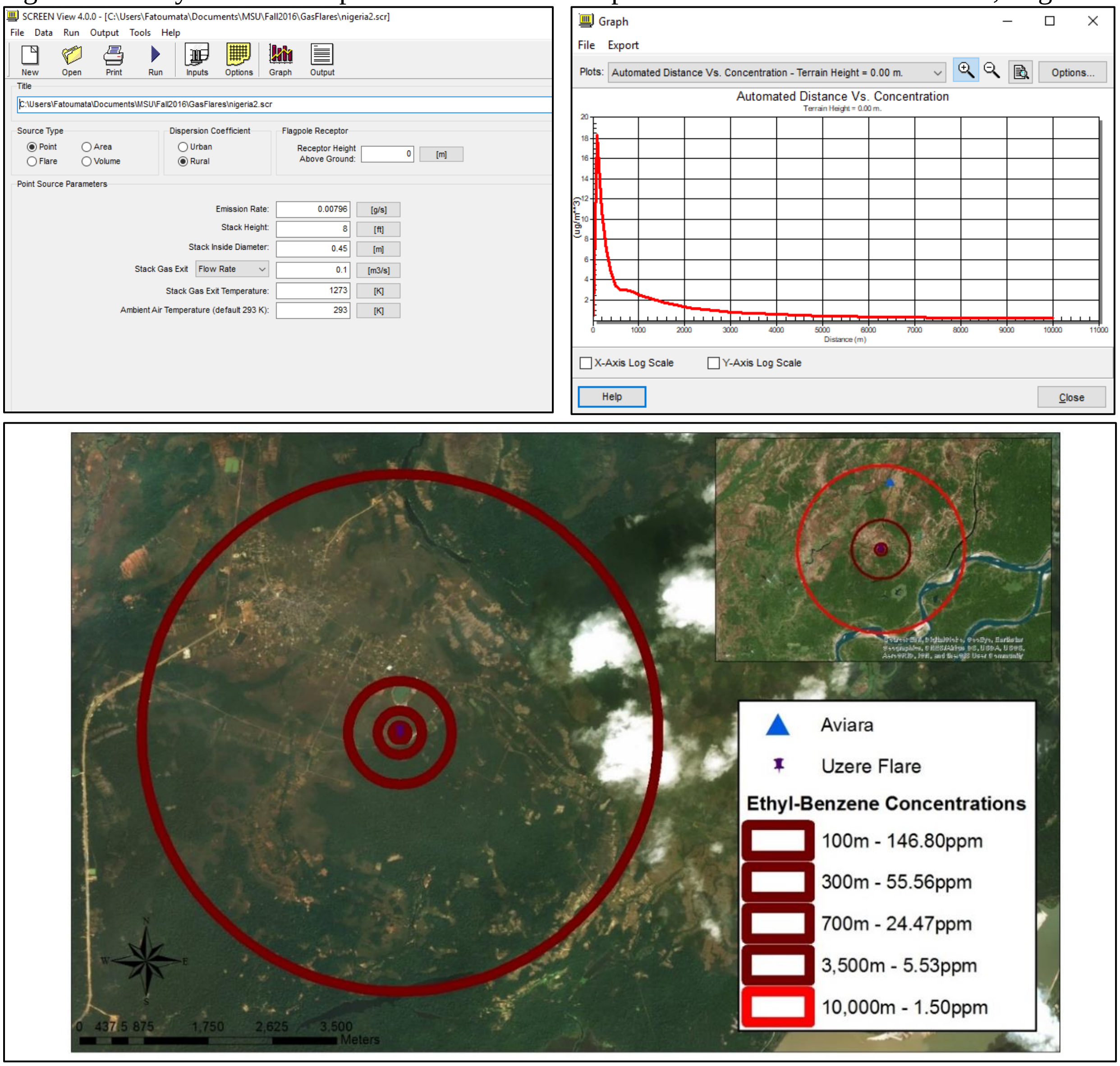
Figure 4-7: Styrene Input Parameters and Output Concentrations – Uzere Flare, Nigeria.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

Ethyl-benzene concentrations ranged from 18.35 ppm/hour immediately surrounding the gas flare to 0.19 ppm/hour at 10,000m from the flare (Figure 4-8 and Table B-2). Cal/OSHA's PEL for ethyl-benzene is 5.0 ppm/8-hour day. Ethyl-benzene substantially exceeded Cal/OSHA's PEL if the flare was operational for at least 8 hours a day; immediately surrounding the flare (146.80 ppm) to 3,500–4,000m from the flare (5.53–4.70 ppm). The ATSDR Chronic MRL for ethyl-benzene is 0.06 ppm/24-hour day. Ethyl-benzene was substantially above the ATSDR Chronic MRL if the flare was operational for 24 hours a day; immediately surrounding the flare (440.40 ppm) to 10,000m (4.51 ppm). Thus, the concentration of ethyl-benzene is excessively high in Uzere for Cal/OSHA's PEL and the ATSDR Chronic MRL, but Cal/OSHA's PEL only exceeded at 3,500–4,000m which encompasses all of Uzere community. Ethyl-benzene concentrations reduced quite substantially at the 10,000m perimeter, which encompasses Aviara community.

Figure 4-8: Ethyl-Benzene Input Parameters and Output Concentrations – Uzere Flare, Nigeria.



Sources: Gas Flare Coordinates: National Oceanic and Atmospheric Administration (NOAA) et al., 2016; Toxic Chemicals Concentrations: Argo, 2001; Community Boundaries: Google Maps, 2018; World Imagery Base Map: Environmental Systems Research Institute (ESRI) et al., 2018. Map created by Fatoumata B. Barry, 2018.

4.6.2. Health Assessment

4.6.2.1. Descriptive Results

All of the women surveyed in both Uzere and Aviara were Isoko (Table 4-2). The group surveys revealed that there were no foreigners surveyed and both communities had similar levels of education and socio-economic status, except for a few differences (Table 4-2). The average age of all women surveyed was 42 years (range, 18–80 years of age). Uzere respondents were slightly older with 24.00 percent between the ages of 56 and 80 years old compared 12.96 percent for Aviara women surveyed. There were 199 women surveyed in both communities that had at least one child 12 years of age and younger in their household. Uzere women surveyed had slightly lower levels of education than Aviara women surveyed with 42.00 percent of Uzere women surveyed with no education compared to 25.00 percent of Aviara women surveyed with no education. In terms of socio-economic indicators, Uzere women surveyed had slightly lower levels of socio-economic status than Aviara women surveyed. Uzere women surveyed had 14.00 percent with income from paid employment or a non-farm business, 32.00 percent owned generators, 38.00 percent owned a television, 18.00 percent owned a refrigerator, 18.00 percent owned livestock, 22.00 percent had a toilet in their homes, and 16.00 percent had a savings account. However, Uzere women surveyed had slightly higher levels of owning a home (47.00 percent), access to borehole/protected well (96.00 percent), and access to micro-credit loans (60.00 percent) compared to Aviara women surveyed.

Table 4-2: Demographic and Socio-Economic Indicators between Women Surveyed in Uzere and Aviara, Delta state, 2016.

Categorical variable	Uzere (High risk) (%)	Aviara (Low risk) (%)
Residents		
Isoko	100.00	100.00
Foreigners	0.00	0.00
Age		
18-35	33.00	46.30
36-45	21.00	18.52
46-55	22.00	22.22
56-80	24.00	12.96
Education		
No education	42.00	25.00
Primary education	45.00	56.48
Secondary education	8.00	12.04
University or more	5.00	6.48
Socio-economic indicators		
Own house	47.00	31.48
Paid employment/ non-farm business	14.00	35.19
Access to a borehole/protected well	96.00	77.78
Own a generator	32.00	60.19
Own a TV	38.00	58.33
Own a refrigerator	18.00	27.78
Own livestock	18.00	30.56
Own toilet	22.00	43.52
Opened a savings account	16.00	30.56
Micro-credit loan	60.00	30.56

4.6.2.2. Multi-Variable Logistic Regression

Symptoms and Health Conditions of Women

Table 4-3 reports the results from the survey of women in Uzere and Aviara. Women were asked about the most common symptoms and health conditions "in the last four months" (rainy season) that they experienced. Women in Uzere reported a higher odds of the following symptoms/health conditions in order of importance: arthritis pain, OR=20.23 (95% CI, 9.98–41.00); ulcers, OR=5.61, (95% CI, 2.32–13.55); general pain during house cleaning and working, OR=4.25 (95% CI, 1.63-11.08), pain while walking, OR=2.69 (95% CI, 1.40-5.17), chest pain, OR=2.01 (95% CI, 1.04-3.86), and syndemics –i.e., "acquiring one symptom/ health condition after the other," OR = 2.34 (95% CI, 1.33–4.11). Women in Uzere reported feeling better in the dry season compared to women in Aviara, OR=3.75 (95% CI, 1.88-7.48). Women in Uzere reported a lower odds of malaria, OR=0.36 (95% CI, 0.20-0.66), constipation, OR=0.48 (95% CI, 0.24-0.96) and stomach issues, OR=0.56 (95% CI, 0.31-0.96).

Table 4-3: Symptoms and Health Conditions Reported by Women Surveyed in Uzere vs. Aviara, Delta state, 2016.

						Odds Ratio		
			Fisher's Exact Test			**95% Confidence Interval**		
Variables	**Communities**	**N**	**Value**	**df.**	**p-value**	**Value**	**Lower**	**Upper**
Vaccinated in primary school	Uzere	100	1.01	1	0.32	0.75	0.43	1.32
	Aviara	108						
Limited in spending due to health	Uzere	100	2.31	1	0.17	1.53	0.88	2.64
	Aviara	108						
Symptoms/Health conditions								
Walking	Uzere	100	**9.19**	**1**	**0.00**	**2.69**	**1.40**	**5.17**
	Aviara	108						
Eating	Uzere	100	2.57	1	0.12	0.57	0.29	1.14
	Aviara	108						
Drinking	Uzere	100	0.54	1	0.68	0.53	0.10	2.96
	Aviara	108						
House Cleaning/ Working	Uzere	100	**9.91**	**1**	**0.00**	**4.25**	**1.63**	**11.08**
	Aviara	108						
Fetching water/ carrying heavy load	Uzere	100	1.63	1	0.24	1.46	0.82	2.59
	Aviara	108						
Bodily Pain/ discomfort per year	Uzere	100	3.21	1	0.09	0.50	0.23	1.08
	Aviara	108						
Chest pain	Uzere	100	**4.44**	**1**	**0.05**	**2.01**	**1.04**	**3.86**
	Aviara	108						
Arthritis	Uzere	100	**83.89**	**1**	**0.00**	**20.23**	**9.98**	**41.00**
	Aviara	108						
Malaria	Uzere	100	**11.29**	**1**	**0.00**	**0.36**	**0.20**	**0.66**
	Aviara	108						
Diarrhea	Uzere	100	0.49	1	0.58	1.48	0.49	4.42
	Aviara	108						

Table 4-3 (cont'd)

Stomach issues	Uzere	100	**4.44**	**1**	**0.05**	**0.55**	**0.31**	**0.96**
	Aviara	108						
Constipation	Uzere	100	**4.37**	**1**	**0.04**	**0.48**	**0.24**	**0.96**
	Aviara	108						
Vomiting	Uzere	100	**4.13**	**1**	**0.06**	**3.21**	**0.99**	**10.45**
	Aviara	108						
Fever	Uzere	100	0.52	1	0.49	0.82	0.47	1.41
	Aviara	108						
Typhoid	Uzere	100	0.09	1	0.85	0.89	0.43	1.85
	Aviara	108						
Rash	Uzere	100	2.64	1	0.11	1.94	0.86	4.33
	Aviara	108						
Ulcer	Uzere	100	**17.18**	**1**	**0.00**	**5.61**	**2.32**	**13.55**
	Aviara	108						
Chronic								
Symptoms come one after the other?	Uzere	95	**8.83**	**1**	**0.00**	**2.34**	**1.33**	**4.11**
	Aviara	108						
Seasonal Health								
Season of the year - most bodily pain	Uzere	41	**3.94**	**1**	**0.06**	**2.39**	**1.00**	**5.72**
	Aviara	62						
Health better - rainy season - this or last year	Uzere	86	0.01	1	1.00	1.03	0.56	1.89
	Aviara	92						
Health better- dry season - this or last year	Uzere	75	**14.80**	**1**	**0.00**	**3.75**	**1.88**	**7.48**
	Aviara	84						

Symptoms and Conditions during Pregnancy

As mentioned above, women in Uzere reported a lower odds of malaria compared to women in Aviara; however, during pregnancy, women in Uzere reported a higher odds of malaria, OR=1.81 (95% CI, 1.02-3.20) compared to women in Aviara (Table 4-4). Women surveyed in Aviara were less likely to go to a hospital or clinic while pregnant and during birth compared to Uzere women, OR=0.41 (95% CI, 0.20-0.85). All other health concerns during pregnancy were similar for women living in Uzere and Aviara, including birth complications in the dry and rainy seasons.

Table 4-4: Symptoms and Health Conditions during Pregnancy in Women Surveyed in Uzere vs. Aviara, Delta state, 2016.

						Odds Ratio		
			Fisher's Exact Test			**95% Confidence Interval**		
Variables	**Communities**	**N**	**Value**	**df.**	**p-value**	**Value**	**Lower**	**Upper**
Have children under 12 years of age	Uzere	51	2.58	1	0.12	0.64	0.37	1.11
	Aviara	67						
Children under 12 years of age in household	Uzere	44	0.01	1	1.00	0.95	0.24	3.80
	Aviara	37						
Health services during pregnancy								
Vaccinated	Uzere	92	0.29	1	0.65	0.85	0.47	1.53
	Aviara	91						
Physical exam	Uzere	95	1.20	1	0.31	0.73	0.41	1.29
	Aviara	104						
Gynecological exam	Uzere	95	0.30	1	0.67	1.17	0.67	2.04
	Aviara	104						
Ultrasound	Uzere	95	1.98	1	0.20	0.67	0.38	1.17
	Aviara	104						
HIV/ STD testing	Uzere	95	0.74	1	0.46	0.78	0.43	1.39
	Aviara	104						
Blood tests	Uzere	95	3.00	1	0.09	0.61	0.35	1.07
	Aviara	104						
Nutrition	Uzere	95	3.31	1	0.08	1.70	0.96	3.03
	Aviara	104						
Tetanus vaccine	Uzere	95	0.50	1	0.57	1.22	0.70	2.15
	Aviara	104						
No hospital	Uzere	95	**6.01**	**1**	**0.02**	**0.41**	**0.20**	**0.85**
	Aviara	104						

Table 4-4 (cont'd)

Symptoms during pregnancy								
Malaria	Uzere	95	**4.16**	**1**	**0.05**	**1.81**	**1.02**	**3.20**
	Aviara	104						
Blood issues	Uzere	95	0.31	1	0.67	1.66	0.27	10.17
	Aviara	104						
Chest pain	Uzere	95	1.35	1	0.31	2.27	0.55	9.34
	Aviara	104						
Stomach pain	Uzere	95	0.21	1	0.78	1.30	0.42	4.01
	Aviara	104						
Diarrhea	Uzere	95	4.39	1	0.05	4.69	0.97	22.67
	Aviara	104						
Constipation	Uzere	95	2.66	1	0.16	2.20	0.84	5.76
	Aviara	104						
Vomiting	Uzere	95	0.02	1	1.00	0.95	0.49	1.83
	Aviara	104						
Fever	Uzere	95	0.01	1	1.00	1.02	0.55	1.91
	Aviara	104						
Typhoid	Uzere	95	1.42	1	0.32	1.81	0.67	4.89
	Aviara	104						
Pregnancy complications								
Last born - what season born?	Uzere	95	0.93	1	0.39	1.32	0.75	2.30
	Aviara	104						
Born in the rainy season – complications	Uzere	41	0.00	1	1.00	0.98	0.33	2.91
	Aviara	52						
Born in the dry season complications	Uzere	54	0.20	1	0.71	0.71	0.15	3.32
	Aviara	52						

Symptoms and Conditions of Children

Table 4-5 reports when women were asked about their children's health or children in their household 12 years of age and younger in the "last four months" (rainy season). The most common symptoms and health conditions of children in Uzere compared to Aviara, in order of importance, were: diarrhea, OR=8.01 (95% CI, 3.62-17.75), rash, OR=6.09 (95% CI, 2.52-14.72), asthma diagnosis, OR=5.22 (95% CI, 2.02-13.47), chest pain, OR=4.03 (95% CI, 2.12-7.64) and malaria, OR=1.77 (95% CI, 1.00-3.13). Children in Aviara had a significantly lower odds of being vaccinated by a doctor/nurse in a hospital/clinic, OR=0.39 (95% CI, 0.32-0.47), last born receiving Vitamin A supplementation, OR=0.03 (95% CI 0.01-0.12), and were less likely to have chest pain, OR=0.15 (95% CI 0.94-0.56). Women in Uzere reported a higher odds of low protein intake in their children 12 years and younger, OR=0.26 (95% CI, 0.14-0.46); while women in Aviara were significantly more likely to give their child protein within 2 weeks after finishing breastfeeding, OR=0.26 (95% CI, 0.14-0.46). Interestingly, mothers in Uzere were more likely to report that their child's health was better during the dry season compared to the rainy season, OR=4.90 (95% CI, 2.45-9.79).

Table 4-5: Symptoms and Health Conditions in Children in Households of Women Surveyed in Uzere vs. Aviara, Delta state, 2016.

					Odds Ratio		
			Fisher's Exact Test		95% Confidence Interval		
Variable	**Community**	**N**	**Value**	**p-value**	**Value**	**Lower**	**Upper**
Vaccinations							
Children vaccinated	Uzere	95	0.35	0.67	1.29	0.56	2.96
	Aviara	104					
Vaccinated by doctor/nurse in clinic/hospital	Uzere	94	**44.00**	**0.00**	**0.39**	**0.32**	**0.47**
	Aviara	95					
Paid for child's vaccination	Uzere	95	3.41	0.09	4.06	0.82	20.04
	Aviara	104					
Last born received vitamin A supplementation	Uzere	82	**46.98**	**0.00**	**0.03**	**0.01**	**0.12**
	Aviara	98					
Symptoms and health conditions of children							
Limited in playing sports?	Uzere	95	0.11	0.77	1.10	0.62	1.97
	Aviara	104					
Limited in eating?	Uzere	95	3.40	0.08	1.70	0.97	3.00
	Aviara	104					
Limited in drinking?	Uzere	95	0.21	0.66	1.22	0.51	2.92
	Aviara	104					
Limited in house cleaning?	Uzere	95	1.44	0.29	1.44	0.79	2.61
	Aviara	104					
Limited in fetching water or carrying heavy load?	Uzere	95	0.37	0.55	1.20	0.67	2.16
	Aviara	104					
Child pain and discomfort - times?	Uzere	87	**10.15**	**0.00**	**0.15**	**0.04**	**0.56**
	Aviara	80					
Chest pain	Uzere	95	**19.27**	**0.00**	**4.03**	**2.12**	**7.64**
	Aviara	104					

Table 4-5 (cont'd)

Malaria	Uzere	95	**3.93**	**0.06**	**1.77**	**1.00**	**3.13**
	Aviara	104					
Diarrhea	Uzere	95	**31.42**	**0.00**	**8.01**	**3.62**	**17.75**
	Aviara	104					
Stomach pain	Uzere	95	0.91	0.39	1.32	0.75	2.33
	Aviara	104					
Constipation	Uzere	95	0.21	0.67	1.22	0.53	2.81
	Aviara	104					
Vomiting	Uzere	95	0.55	0.48	0.77	0.38	1.55
	Aviara	104					
Fever	Uzere	95	0.93	0.39	0.76	0.43	1.33
	Aviara	104					
Typhoid	Uzere	95	0.83	0.49	1.53	0.61	3.80
	Aviara	104					
Rash	Uzere	95	**18.97**	**0.00**	**6.09**	**2.52**	**14.72**
	Aviara	104					
Child diagnosed with asthma	Uzere	95	**13.56**	**0.00**	**5.22**	**2.02**	**13.47**
	Aviara	104					
Syndemic							
One symptom after the other?	Uzere	80	3.34	0.08	1.78	0.96	3.32
	Aviara	83					
Nutrition							
Low protein intake 12 and under	Uzere	95	**5.78**	**0.02**	**2.06**	**1.14**	**3.73**
	Aviara	104					
Breastfed your last born?	Uzere	95	**0.85**	**0.62**	**2.79**	**0.29**	**27.31**
	Aviara	104					
Gave child protein (within 2 weeks) after finished breastfeeding?	Uzere	95	**21.31**	**0.00**	**0.26**	**0.14**	**0.46**
	Aviara	104					

Table 4-5 (cont'd)

Protein intake btw 6 months to 5 years old? (per week)	Uzere	33	0.00	1.00	1.01	0.43	2.37
	Aviara	68					
Seasonal health							
Child health worse this year's rainy season	Uzere	73	1.72	0.22	1.59	0.79	3.17
	Aviara	88					
Child health better during dry season	Uzere	**79**	**21.53**	**0.00**	**4.90**	**2.45**	**9.79**
	Aviara	82					

4.7. DISCUSSION and RECOMMENDATIONS

These qualitative and quantitative findings provide insights into whether oil-producing communities experience worse health concerns and outcomes than non-oil communities in the midst of recurring and severe flooding events. It is necessary to advance our understanding of the ways in which climate variability and land use activities such as oil and gas production affect the health of the most vulnerable populations. Oil-producing communities in the Niger Delta have been disenfranchised, marginalized, and have been forced into a cycle of poverty due to the poor standard of living in their communities (Watts, 1999; Ibeanu, 2000; Ikelegbe, 2001; Ukiwo, 2007; Omotola, 2009). The increasing severity of floods may put further stress on an already vulnerable population leading to higher levels of morbidity and premature mortality, and in some cases eco-syndemics. When human bodies are exposed to infectious agents and environmental pollutants, the immune system is compromised, increasing susceptibility to other ailments and infections. The oil and gas industry in the Niger Delta is known to release toxic pollutants through oil spills and gas flares, which have increased health hazards in communities close to their activities (Ana et al., 2009; Gobo et al., 2009). Recurring and severe flooding may lead to NaTech events potentially worsening health hazards, including eco-syndemics (Baer and Singer, 2009; Singer, 2013b; Bulled et al., 2014). Individuals are more vulnerable to eco-syndemics if they live and/or work in a region with clusters of diseases as well as regions with failed support systems and reduced access to quality health services (Singer, 2013a). There are very limited studies conducted on the health consequences of a changing climate, including the complexities of eco-syndemics in communities with pre-existing vulnerabilities due to the oil and gas industry. This section will provide an in-depth discussion about the results of the gas flare assessment and the health concerns, diseases and conditions related to the oil and gas industry activities, particularly the carcinogenic impacts of the chemicals released by gas flares. A discussion on the statistical analysis of the group surveys and the potential eco-syndemics present in oil-producing communities follows.

4.7.1. Gas Flares, Cancer Risks and Other Health Consequences

The Uzere oil facility has two horizontal gas flares, but only one gas flare was assessed to provide a baseline. All chemicals assessed in SCREEN View 4 reached a distance of 10,000m encompassing Uzere community at greater concentrations and Aviara community at lower concentrations (Figure 4-3). However, it is important to note that depending on wind direction, only certain areas within the radius will be impacted. As noted in the results section, the Cal/OSHA's PELs and Chronic MRLs were used to assess risk. All the chemicals were substantially greater than the Chronic MRLs with benzene having the greatest impact of all chemicals assessed (Table B-1). Exposure above the Chronic MRLs does not necessarily mean that adverse health effects will occur as it is mostly used as a screening tool by public health professionals to identify hazardous sites that may be of concern (ATSDR, 2007). Therefore, the ATSDR will take a closer look at facilities in the United States that release chemicals that are excessively over the MRLs such as those in Uzere.

Benzene had the farthest distance of maximum concentrations above Cal/OSHA's PELs, reaching 10,000m (Figure 4-4). The Uzere oil facility and its outskirts are between 100–300m and was 214.80–81.28 times over the Cal/OSHA PEL. We were informed by oil workers during a field visit in November 2016 at the Uzere oil facility that they use protective respirators when the oil facility is in operation. However, there is evidence that at some point in time, community members used the Uzere gas flares to dry tapioca, which is a cassava-based food, that they sold and ate, and they did not wear protective respirators (Deutsche Welle, 2015). Therefore, some community members were being exposed to pollutants via inhalation close to the flares and ingestion if the tapioca was eaten. Some of the oil workers live within 700m of the gas flare site and this could have detrimental impacts on their health since benzene concentrations were 81.27 to 35.82 times higher than the Cal/OSHA PEL (Figure 4-4). All Uzere residences, farms, schools, clinics, and small businesses are within 3,500m from the gas flare, which have benzene concentrations from 35.81 to 8.09 times higher than the Cal/OSHA PEL. Aviara, which is located between 7,500m and 10,000m from the gas flare, is also potentially exposed to benzene at 3.14 to 2.20 times greater than the Cal/OSHA PEL (Figure 4-4). Although these benzene concentrations are double or triple the Cal/OSHA PEL in Aviara, they are still substantially lower than the exposure in Uzere.

Toluene and styrene were above Cal/OSHA's PEL from the gas flare to around 300m, which mostly encompasses the oil facility. Between 300m and 400m, toluene and styrene concentrations were slightly above the Cal/OSHA's PEL where lodging for oil workers begins. Toluene concentrations were 3.36 to .27 times higher than the Cal/OSHA's PEL between 100 and 300m (Figure 4-5.). Styrene concentrations were 2.78 to 1.05 times higher than the Cal/OSHA's PEL between 100 and 300 meters (Figure 4-7). Ethyl-benzene was above Cal/OSHA's PEL from the gas flare to around 3,500m, which encompasses all of Uzere community. Ethyl-benzene concentrations were 29.36 to 1.11 times higher than Cal/OSHA's PEL from the flare site to 3,500m (Figure 4-8). Xylenes were not above Cal/OSHA's PEL (Figure 4-6).

During the site visit in November 2016 (Figure 4-9), the Uzere oil facility was not operational because there were mechanical issues (pipeline that transports oil was being fixed). The chemicals released may potentially reach Aviara, but in smaller quantities. The SCREEN View 4 model is limited in assessing specific terrain and what could potentially block the dispersion of the chemicals. It also assesses chemicals individually and does not consider what occurs once the chemicals are released into the atmosphere and how they interact. SCREEN View 4 also does not allow the user to include specific meteorology information and uses meteorology information that provides the worst-case scenario. The SCREEN View 4 model assumes 100.0 percent combustion efficiency, which is most likely not the case. In Argo's (2001) study, it was found that combustion was inefficient in flaring due to winds and heating value of the fuel, leading to release of raw fuel. Sweet gas plumes in Canada during light winds had a lower combustion efficiency than sour gas plumes; 64.0 percent and 84.2 percent, respectively (Argo, 2001). Abdulkareem (2005) found that gas flares in Nigeria have a combustion efficiency of approximately 60.0 to 80.0 percent, which signifies that 20.0 to 40.0 percent of the flared gas is released as hydrocarbon, while the remaining goes through combustion. Therefore, there is a possibility of higher concentrations of chemicals and pollutants when combustion efficiency is lowered. Also, each chemical released vaporizes for a certain amount of days. For instance, benzene, when released in the atmosphere, exists as a vapor for approximately 13.4 days (Nova Chemicals, 2017).

Figure 4-9: Pictures from Uzere Oil Facility Visit, 2016.

From left to right (upper): Horizontal gas flare (left side); Horizontal gas flare (right side).
From left to right (lower): Extracted oil (left side); Sign of Uzere Compressor Station (right side).
Source: Pictures taken by Fatoumata B. Barry (2016).

Although there are a vast amount of chemicals and pollutants released from gas flares that implicate health, the following paragraphs will focus on the health consequences and its potential carcinogenic effect from exposure to each chemical assessed in this study. Benzene is a known carcinogen. According to the ATSDR (2007), long-term exposure to benzene may affect the tissues that form blood cells, especially bone marrow. It may disrupt normal blood production leading to anemia and in some cases, excessive bleeding. One study conducted in Oganiland in Rivers state found that there were a higher proportion of residents that were diagnosed with anemia after being chronically exposed to benzene from oil spills (Kponee et al., 2015). Long-term exposure to benzene can also impact the immune system increasing the chances of infection and cancer, particularly leukemia (ATSDR, 2007). A study by Omoti et al. (2006) found that chronic lymphoid leukemia was quite common in southern Nigeria at similar levels of industrial countries with higher prevalence among women.

In terms of women's health, benzene may be harmful to reproductive organs when high levels are inhaled (ATSDR, 2007). These may include a decrease in size of the ovaries and low birth weight, delayed bone formation and bone marrow damage on a developing fetus. One study conducted in Akwa Ibom state (Niger Delta) found that embryonal cancer (germ cell tumor found in the ovaries and testes) was the most common cancer in young patients 14 years and under, with female patients at three times more risk of all cancers examined (Abudu and Akinbami, 2016). The researchers also found that breast cancer and soft tissue sarcoma (cancer that begins in the tissues that connect, support and surround other body structures) were two of the most common cancers in young patients between the ages of 5 to 30 years. Embryonal cancer and soft tissue sarcoma are both very rare cancers. Another study found that 74.0 percent of girls and women (n=450) between the ages of 10 and 70 years that had a pap smear exam in Bayelsa state (Niger Delta) had atypical squamous cells signifying an infection or certain types of human papillomavirus (HPV) (Oboma and Onyije, 2012). Cervical cancer is common in Nigeria as HPV-related cancers are the second most frequent cancer among women in Nigeria with a crude incidence rate of 17.1 (Catalan Institute of Oncology and the World Health Organization's International Agency for Research on Cancer [ICO/ WHO-IARC], 2017). It is unclear, however, of the regional differences in the rates and types of cancers in Nigeria.

Chronic exposure from low to moderate levels of toluene in the workplace may potentially lead to tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, and loss of appetite in some people (ATSDR, 2017). Children are also more susceptible to toluene than adults. Toluene may cause neurological effects, speech, vision, hearing, loss of muscle control, loss of memory, poor balance, and decreased mental ability in people exposed daily to toluene in the workplace (ATSDR, 2017). Toluene exposure during pregnancy may lead to spontaneous miscarriages and developmental and growth effects in children (ATSDR, 2017). Women have complained about miscarriages in oil-producing communities in the Niger Delta (Ana et al., 2009; ERA, 2008; interviews with Uzere Representatives, 2014). Georgewill (2012) has found that rats exposed to Nigerian crude oil had frequent miscarriages. Future studies should be conducted to determine the stillbirth rates and/or whether the oil industry is the main contributor of these miscarriages.

The three forms of xylenes have very similar effects on health. Short- and long-term exposure to high levels of xylenes may cause neurological problems such as headaches, lack of muscle coordination, dizziness, confusion, and changes in balancing (ATSDR, 2007). Children may be more susceptible to xylenes because of their narrower airways. It was also found that women also have narrower airways which made breathing more difficult after inhaling xylenes compared to men (ATSDR, 2007). Pregnant women exposed to high levels of xylenes may also harm the fetus as animal studies have found that it may cross the placenta. After birth, reduced body weight, delayed bone mineralization, and motor coordination problems for infants is possible after high-level exposure to xylenes.

The International Agency for Research on Cancer has determined that styrene is a possible carcinogen (ATSDR, 2010). High-level exposure to styrene may cause neurological damage such as changes in color vision, tiredness, slowed reaction time, concentration problems and balance problems (ATSDR, 2010). Studies are inconclusive on the health impacts of children such as their susceptibility, birth defects, and low birth weight. Mothers can expose their infant to styrene through breastfeeding.

The International Agency for Research on Cancer has determined that long-term exposure to ethyl-benzene may cause cancer in humans (ATSDR, 2010). Short-term exposure to high-levels of ethyl-benzene can cause eye and throat irritation, vertigo and dizziness (ATSDR, 2010). Long-term exposure to low concentrations of ethyl-benzene may cause irreversible damage to the inner ear, kidney damage, and tumors in kidneys, lung and liver in animals. However, in younger animals, ethyl-benzene produced birth defects and low birth weight. A study in Rivers state (Niger Delta) found that more children are born with nervous system birth defects at the University of Port Harcourt Teaching Hospital than in other regions in Nigeria (Abbey et al., 2017). This could be linked to the exposure of toxic chemicals released by gas flares and ingestion of oil-contaminated food/water by a mother before or while pregnant. It is not known whether children are more susceptible to ethyl-benzene.

The carcinogen effects of the chemicals released by gas flares are concerning, particularly among fetuses, children, and women, due to the higher levels of susceptibility to acute and chronic exposures of these types of toxins. One interesting pattern among all chemicals assessed is that they all effect the nervous system, except for benzene. The higher levels of nervous system abnormalities among children in the Niger Delta in Abbey et al. (2017) study compared to other regions in Nigeria may be a clear sign that more epidemiological studies must be conducted to determine if indeed, the oil and gas industry is creating this difference. Screening for certain cancers linked to industrial activities must also increase because oil and non-oil producing populations are potentially impacted by the toxic chemicals and pollutants. However, specific attention has to be given to oil-producing communities due to their proximity to the hazards and the potentially more complex health conditions that they experience.

The international community and the Nigerian Government are working towards reducing gas that is flared. There are certain technologies that can be put in place in some oil-producing communities in the Niger Delta to turn the natural gas burned through gas flaring into a commodity. The Nigerian Government has founded the Nigeria Gas Flare Commercialization Program in 2016 to mobilize the private sector towards gas flare capture projects to turn it into liquefied petroleum gas for the benefit of Nigerians (Sweet Crude Reports, 2017). The main reason that gas is flared is because companies do not want to invest in the infrastructure to reduce the flaring. The World Bank initiated a public-private partnership, Global Gas Flaring Reduction Partnership (GGFR), with international oil companies, national governments and other international institutions to reduce gas flared around the world. In 2017, the World Bank (2017) began to accept proposals for their initiative called “Zero Routine Flaring by 2030,” to financially support companies with viable solutions to try to monetize the flared gas. Gas flaring has impacted communities for decades and has possibly created a whole generation prone to chronic diseases and premature mortality.

Future studies should investigate the concentrations and the extent of all chemicals and pollutants released from gas flares in the Niger Delta, including former oil-producing communities that are no longer exposed to gas flares as they may still be at increased risk. Although some of the health consequences of the oil and gas industry were discussed in this section, the following paragraphs will focus on the results from the group surveys implemented in November 2016 to determine the health symptoms and conditions that are of greatest concern and whether eco-syndemics are present in the communities. Also, to protect the women from undue fear, the survey did not ask direct questions about cancer and other acute and chronic diseases as outlined above. Instead the survey focused on symptoms and health conditions of women and children as perceived as important in their everyday lives.

4.7.2. The Health of Women and Children Exposed to Gas Flares and Flooding

The health symptoms and conditions cited by women surveyed in Uzere are consistent with oil pollution and flooding. The health consequences of the oil and gas industry are the ones that are typically observed in poorer regions of the world as these populations suffer in the midst of poverty and environmental exploitation (UNDP, 2006; Nkowcha and Egejuru, 2008; Ana et al., 2009; Gobo et al., 2009). Flooding may also increase exposure to pollutants from oil spills in waterways and soil, thus augmenting contamination of fresh water and food sources (Appel, 2005; Dung et al., 2008). These flood-related conditions have led to adverse health consequences in sub-Saharan Africa with an increased risk of developing skin rashes, ingesting toxic foods, and epidemics of cholera, malaria, and rift-valley fever (Epstein, 2000).

As in many marginalized communities, women and children in the Niger Delta tend to be the most vulnerable and have worse health outcomes due to their exposure to oil and gas industry pollutants, higher levels of poverty and inadequate access to quality health services and vaccine-preventable immunizations (UNDP, 2006; Nkowcha and Egejuru, 2008; Ana et al., 2009; Gobo et al., 2009; Antai, 2011; Mustapha et al., 2013). Other factors include susceptibility due to pregnancy and pre-existing conditions. Studies have shown that pregnant women are more susceptible to infectious diseases due to a unique immune condition that that puts them and their fetus at increased risk, particularly in the first half of their pregnancy (Jamieson et al., 2006; Mor and Cardenas, 2010; Singer, 2013a). Additionally, pregnant women who have pre-existing health conditions are at an increased risk of complications during pregnancy and at birth. For instance, pregnant women with HIV have increased mortality rates due to the aggravated effect that pregnancy has on HIV (WHO, 2013). Pregnant women who are co-infected with malaria and HIV are more likely to have complications during pregnancy due to the compounded effects of both diseases on the body (Uneke and Ogbonna, 2009).

Children are also more susceptible to infection and diseases than adults. Children tend to grow in phases called "developmental windows" and when exposed to certain environmental hazards, these can lead to serious developmental delays and health consequences (Sly and Flack, 2008). The children of the Niger Delta today have potentially been more exposed to oil pollution than their parents and grandparents and are therefore, more likely to live longer with toxic damage that can manifest into disease. Furthermore, recent studies have shown that there are other factors such as the mother's health that influence child morbidity and premature mortality. Exposure to toxic chemicals leading to poor health of women before and during pregnancy may impact children's health (Bruederle and Hodler, 2017). Nutritional deficiencies in pregnant women may also impact the health of their children. Severe iodine deficiency during pregnancy has been known to lead to intellectual impairment and neurological abnormalities in children (Haddow et al., 1999; Norris et al., 2014). Iron deficiency has been found to lead to impaired motor development, coordination and scholastic achievements in children (Norris et al., 2014). The next few paragraphs will outline some of the main health conditions that women and children in Uzere were more likely to experience compared to Aviara women.

4.7.2.1. Asthma

Women surveyed in Uzere were 2.01 times more likely to experience chest pain than Aviara women surveyed. Children in Uzere were 5.22 times more likely to be diagnosed with asthma by a physician, 4.03 times more likely to experience chest pain, and 6.09 times more likely to develop rashes compared to children in Aviara. Respiratory illnesses are prevalent in the Niger Delta and asthma is the world's most common, long-term condition that is not curable (Desalu et al., 2011). Children are the most susceptible group to this disease because their lungs are not fully developed at the time of exposure to irritants and allergens that exacerbate atopy (Weinberg, 1999). This is most likely directly linked to the chemicals released by the gas flares. Gas flares have been linked to respiratory health issues and rashes. Many studies have found that the principal determinants of asthma prevalence are environmental factors (Burney, 1993; Asher et al., 2006). Studies conducted in developing countries showed that populations that live in very poor rural areas have a lower prevalence of bronchial hyper-responsiveness, but that the prevalence increases as populations move to urban centers (Burney, 1993). There is an urban-rural difference that is very striking in many developing countries where one finds that industrial pollution, motor vehicle exhaust emissions, indoor allergens, and tobacco smoke in urban centers are linked to increased prevalence of asthma (Weinberg, 1999; Mustapha, Blangiardo, et al., 2011). However, populations in rural communities close to agricultural pesticides, other agricultural inputs, and extractive industries (i.e., mining and oil activities) have similar rates of respiratory health issues as urban areas (Weinberg, 1999). Low-income communities in the Niger Delta have less access to healthcare and therefore, people who have the symptoms of asthma such as wheezing, chest tightness, and difficulty breathing typically do not receive an official asthma diagnosis (Gobo et al., 2009; Mustapha et al., 2013; Obaseki et al., 2014).

Also, some studies have shown that allergic reactions such as rashes (i.e., eczema) can be a precursor to asthma –a syndemic interaction (Murray et al., 2006). Risk factors for asthma in the past decade in West Africa have shown that there are numerous triggers to developing the disease. Allergic (rhinitis, eczema, etc.) and non-allergic factors both play a critical role depending on the local context, but children being the most susceptible group stays constant. There are numerous triggers to asthma that are indoors (e.g., tobacco smoke, mold spores, skin cells and hair of animals, dust mites, cockroaches) and outdoors (e.g., vehicle emissions, plant pollen, and cold air) (Adkinson et al., 2007). These triggers are increasingly being considered as eco-syndemic interactions between asthma and rhinitis/rhinosinusitis due to the rising rates of rhinitis (Singer et al., 2013). Several studies since the 1920s and 1930s have found an association between rhinitis and asthma with allergic rhinitis being a risk factor for asthma (Leynaert et al., 2000; Singer, 2013b). More recently, certain scholars have noted that asthma, rhinitis, and rhinosinusitis are all disease expressions that may be progressive manifestations of a common disease process. In other words, once an individual has rhinitis or rhinosinusitis, it may develop into asthma later in life if they are continuously exposed to triggers. Therefore, any exacerbation of current conditions can increase asthma rates in certain regions and this could be considered an eco-syndemic interaction. Although there are no studies on asthma and its eco-syndemic interactions in the Niger Delta, there are a number of studies that have found allergic conditions such as rashes/dermatitis and asthma in populations exposed to oil and gas industry pollution (Ana et al., 2009; Gobo et al., 2009; Mustapha et al., 2013)

Other studies have found potential syndemic interactions between asthma, other viruses, and bacteria. Murray et al. (2006) conducted a case-control study on the synergistic interactions between asthma and respiratory viruses including rhinovirus (cause of the common cold), enterovirus, coronaviruses, RSV, influenza A and B, parainfluenza viruses 1-3, adenovirus, Chlamydophila pneumonia, and Mycoplasma pneumonia. The researchers found that children with asthma (case) had significantly higher risk of being exposed and being sensitive to allergens and of having a higher respiratory pathogen load than children without respiratory conditions (control). The authors concluded that there appears to be a combined rather than an individual effect of a natural virus infection and allergen exposure in allergic children with asthma, exacerbating their asthma. This has been corroborated by other studies including Johnston et al. (1995), who found that 80.0 percent of asthma attacks in children aged 9–11 years were due to a viral infection. A study conducted by Madhi et al. (2000) found that HIV-infected children were predisposed to more frequent and severe lower respiratory tract infections than HIV-uninfected children in Soweto, South Africa. Chlamydophila pneumonia and Mycoplasma pneumonia, which are bacteria, also contribute to asthma attacks and have been associated with adult onset asthma (Brouard et al., 2002; Lieberman et al., 2003; Joao Silva et al., 2007; Singer, 2013b).

Dietary factors also play a role in exacerbating or protecting adults and children from developing asthma and other atopic diseases. For example, Weinberg (1999) found that children in rural areas of South Africa that had lower protein intake, but a diet high in fermented milk with *Lactobacillus*, had faster maturation of their immune systems (Weinberg, 1999). Furthermore, Hopkins (1997) found that populations that have higher intake of vitamin C, omega 3 fatty acids, and salts (i.e., sodium, potassium, and magnesium) might have a lower risk of asthma as these are anti-inflammatory agents (Hopkins, 1997). Children with nutritional deficiencies are potentially at greater risk of developing asthma due to a weakened immune system (Hopkins, 1997; Weinberg, 1999).

Children in Uzere were also 2.45 times more likely of having better health in the dry season compared to the rainy season. Women cited that the rainy season brings with it too many illnesses. However, with higher child asthma rates in Uzere, we would have believed that the dry season would be riskier. For instance, Gobo et al. (2009) found that during the rainy season, particulates from gas flares are reduced due to the effects of the rain, which may reduce respiratory symptoms observed during the dry season. In spite of this, Ruckart et al. (2008) found that toxic air releases from industrial facilities represented 91.4 percent of all releases in preparation for and in the aftermath of Hurricanes Katrina and Rita. Therefore, there is a possibility that during more than normal flooding events, asthma is exacerbated due to potential toxic air releases from damaged oil facilities. Unfortunately, due to lax environmental regulations, it is not mandatory for the oil industry to provide information about toxic releases due to natural hazards such a flooding (Ezeigbo and Picard, 2012). Furthermore, waterborne illnesses thrive during the rainy season and therefore, if children have pre-existing health conditions such as asthma, they may be exacerbated due to the development of malaria, typhoid, diarrhea, and other illnesses prevalent during the rainy season.

4.7.2.2. Diarrhea and Malnutrition

Diarrhea and low protein intake were also more prominent among children in Uzere than Aviara. Children in Uzere were 8.01 times more likely to experience diarrhea than Aviara children. Diarrhea is still the leading cause of death in children under the age of 5 years (United Nations International Children's Fund and the World Health Organization [UNICEF/WHO], 2009; Bulled et al., 2014; Fischer Walker et al., 2013). Over half of the diarrhea cases around the world occurred in sub-Saharan Africa in 2011 (Fisher Walker et al., 2013; Bulled et al., 2014). In Nigeria, diarrhea is more prevalent among households with “no improved source of drinking water” (12%) compared to households “that have an improved source of drinking water” (8%) and it is also more prevalent in rural areas (NPC and ICF Macro, 2009). Mothers with higher education levels are also more likely to meet the minimum dietary diversity for children helping to reduce diarrheal illnesses in Nigeria (Ogbo et al., 2015). Educated mothers tend to introduce solid, semi-solid, and soft foods (complementary foods) to infants at 6 months and older, which is the standard age to introduce these foods. However, there has been a negative trend in recent years where children are receiving complementary foods too early or too late and breastfeeding rates are dropping, which is leading to higher rates of diarrheal diseases and malnutrition in Nigeria (Ogbo et al., 2015).

Chronic diarrhea can lead to syndemic interactions with malnutrition, reduced immunity, an increase in infectious and non-infectious diseases and disorders, and premature mortality (van Eijk et al., 2010; Ostrach and Singer, 2013; Bulled et al., 2014). For example, during the 1992 civil war in Somalia, children’s immune systems were compromised by a combination of the social stress of war and displacement to internal displaced camps (Ostrach and Singer, 2013). Subsequently, contaminated food supplies and diarrheal diseases increased malnutrition two-fold in children in the camps (Moore et al., 1993; Ostrach and Singer, 2013). These impoverished conditions led to the death of 74.0 percent of children under the age of 5 years (46 out of 62 children) in the camps (Moore et al., 1993). It is therefore, the interactions of risk factors and the array of diseases found in children, rather than battlefield injuries that caused the majority of child casualties of war (Ostrach and Singer, 2013). In Kenya, HIV-infected children under the age of 2 years had significantly greater diarrhea episodes than children without HIV (van Eijk et al., 2010). Relatedly, the marginalization experienced by certain groups led to lower socio-economic status, including lower maternal educational levels, limited quality health services, and medical staff shortages, which increased the likelihood of exposure to diarrhea pathogens (Gourlay et al., 2013; Bulled et al., 2014).

Children in Uzere were more likely to experience lower levels of protein intake (2.06 times) than children in Aviara. Lower protein levels could indicate a lack of diversity in foods eaten per day leading to malnutrition. Malnutrition occurs when an individual is not receiving the adequate amount of nutrients through food or other sources. Extensive research has been conducted on the synergistic interactions between diarrhea and malnutrition (Bulled et al., 2014). Fifty-three percent of all diarrheal deaths in children under the age of 5 years has been found to be associated with malnutrition (Kosek et al., 2003). Coutinho et al. (2008) found that in mice, diarrheal episodes on a consistent basis limits nutritional absorption because of the damage to intestinal architecture. It is suggested that this is what is causing the higher morbidity rates and premature mortality among children. Recent studies have also found that certain vaccines such as the rotavirus and oral polio are less effective in children who are malnourished and have two or more diarrheal episodes (Hacque et al., 2014). This is critical because when children get vaccinations in the communities studied, the health workers only check whether the child has a fever in order to determine whether they should get the vaccinations that day. However, if a child is malnourished or has diarrhea symptoms during the time of the vaccination, it may not be as effective.

4.7.2.3. Malaria

Children in Uzere were more likely to have malaria than children in Aviara, but it was not a significant relationship. During pregnancy, women in Uzere also were 1.81 times more likely to experience malaria and 4.69 times more likely to experience diarrhea than Aviara women. Women in Uzere were 2.34 times more likely to experience syndemics (acquiring one symptom/ health condition after the other) than Aviara women. They cited getting malaria right after a diarrheal episode. However, Aviara women were less likely to go to a health facility for prenatal visits or for births. This difference is most likely due to the fact that Shell Petroleum Development Company (SPDC) that used to own the oil facility in Uzere (it is now owned by the Nigerian Government) had a health clinic built in Uzere. Although there is a neighboring hospital and a clinic in Aviara, women either want to maintain traditional customs when it comes to pregnancy and birth or they are unable to pay for health services.

Malaria is transmitted by female Anopheles mosquitoes often causing fever, chills, and flu-like illnesses. Malaria was thought to have been eradicated or contained, but it reappeared in certain regions of the world (Margai, 2011). This disease directly originates from exposure to the changing climatic elements such as excessive heat or cold temperatures, severe storms and flooding events (Baer and Singer, 2009; Margai, 2011). Some scholars have linked malaria outbreaks with increases in temperatures and rainfall in the Highlands of Rwanda and Uganda due to localized warming associated with El Niño (Loevinsohn, 1994; Margai, 2011). Severe flooding in Mozambique in 2000 almost doubled the number of malaria cases during the post-flood phase (Kondo et al., 2002). Others have found that increased rainfall reduces certain endemic diseases such as in Tanzania where flooding flushed out the breeding sites of the Anopheles mosquitoes resulting in lower malaria infection rates (Loevinsohn, 1994).

4.7.2.4. Gastrointestinal Health

Both communities had similar ways of acquiring potable water –mostly through borehole and protected well– and most also did not treat their water. Women in Aviara community complained about stomach pains and constipation, but women in Uzere were 5.61 times more likely to experience ulcers. Peptic ulcers are open sores that develop in the inside lining of the stomach and upper portion of the small intestine. These could be due to *Helicobacter pylori* (H. *pylori*), a bacterium that can be found in the stomach, as there is a strong association with the development of ulcers (Goh et al., 2011; Etukudo et al., 2012). H. *pylori* was first discovered in 1984 and has a world-wide contribution with up to half of the world's population harboring this infection in their stomachs (Perez-Perez et al., 2004; Oluyemi et al., 2012). However, developing countries do have a higher prevalence of this infection. Gastrointestinal diseases have been on the rise around the world. These diseases are considered the leading causes of morbidity and mortality globally (Agbakwuru et al., 2006). The lack of endoscopic facilities in Nigeria leads to many upper gastrointestinal diseases to be diagnosed on clinical grounds with their validity unknown. In Nigeria, the prevalence of H. *pylori* in the population is substantial (Oluyemi et al., 2012). This infection tends to occur during childhood by the age of 5 years, but manifestations of gastrointestinal diseases are not observed until adulthood (Naficy et al., 2000; Etukudo et al., 2012). Collecting data from older women in this study was useful in determining high levels of ulcers because H. *pylori* can live in the stomach lining for decades before it manifests into gastrointestinal health issues.

There are potential eco-syndemic interactions between H. *pylori* and other health conditions. There are multiple pathways to acquire H. *pylori*: faeco-oral (fecal particles ingested orally), oral-oral (oral ingestion such as water), or gastric-oral (exposure to vomiting of someone infected with the pathogen) (Goh et al., 2011; Etukudo et al., 2012). There are conflicting studies on whether there is co-morbidity between H. *pylori* and diabetes. In past studies, particularly in developed countries, a higher prevalence of H. *pylori* was observed in people with diabetes (Oluyemi et al., 2012). However, in more recent studies in Australia and Nigeria, there was no significant association between H. *pylori* and diabetes (Xia et al., 2001; Oluyemi et al., 2012). There are, however, a few studies that have shown that there is a low prevalence of H. *pylori* in HIV-positive people, with no clear explanation (Fialho et al., 2011; Goh et al., 2011). H. *pylori* has also been associated with anemia and stunted child growth (Pacifico et al., 2010; Egorov et al., 2010; Goh et al., 2011).

4.7.2.5. Arthritis

Although in both communities, women are primarily engaged in farming activities, women in Uzere were 20.23 times more likely to experience arthritis pain than in Aviara. Arthritis is the inflammation of one or more joints, causing pain and stiffness that can worsen with age. Women surveyed in Uzere were also 2.69 times more likely to experience pain while walking, 4.25 times more likely to experience pain during house cleaning and working, and were older. It would be expected to have more bodily pain in farm workers than non-farm workers, but there is no explanation why Uzere women experience more arthritis pain. Arthritis has been underreported in sub-Saharan Africa (Adelowo et al., 2010). Studies conducted in sub-Saharan Africa in the 1980s and 1990s found low prevalence of arthritis, particularly rheumatoid arthritis. Some have attributed this to a rarity of certain genetic markers often leading to arthritis (Silman et al., 1993; Adewolo et al., 2010). Others found that signs of arthritis are being suppressed through its synergistic interactions with parasitic diseases (Greenwood et al., 1970; Adewolo et al., 2010). However, more recent studies have found that there is a higher prevalence of arthritis among female patients in Nigeria (Adewolo et al., 2010). Furthermore, some studies have found that exposure to certain toxic chemicals can cause an inflammatory reaction, including arthritis (Meggs, 1993; Guo et al., 1999; Stolt et al., 2005). Guo et al. (1999) found that certain chemicals such as polychlorinated biphenyl (PCB) can interact with hormones and hormonal receptors, which can induce osteoporotic changes. No studies were found related to the chemicals released by the oil and gas industry and arthritis in exposed populations.

4.7.2.6. Summary of Findings

The overall findings of the group surveys show that women and children in Uzere have greater health concerns than women and children in Aviara even though they are both flood-prone.

Uzere is at heightened risk due to oil pollution, which makes them more vulnerable. However, a large epidemiological study will need to be conducted to determine whether the specific health issues and potential eco-syndemics cited are present at these higher levels. It can include a focus on asthma and its interaction with malnutrition, diarrhea, and malaria; malaria and its interaction with malnutrition and diarrhea; arthritis and its interaction with oil and gas pollutants; and ulcers and its interactions with oil and gas pollutants. Also, a focus on the psychological health of the population including the impact of the oil and gas industry on stress and certain mental disorders such as depression and anxiety. Future studies must also investigate whether there are differences in health outcomes in oil-producing communities that are high-flood risk and oil-producing communities that are low-flood risk. This will help determine whether flooding is essentially exacerbating health outcomes in oil-producing communities.

4.8. LIMITATIONS

First, this study is meant to be an initial examination of health risks in Niger Delta oil-producing communities. It is not meant to be generalizable across the state and the region because it is prone to the ecological fallacy, which is when studies are conducted and analyzed at the group-level and it is assumed that it can be applied to associations at the individual level. It is believed that this research could bring some insights for a larger epidemiological study in the future. Second, the many communities across Delta state are oil-producing and there are gas flares from other communities in the vicinity of Uzere and Aviara. Therefore, there is the potential of increased health risks for both of these communities. Third, SCREEN View 4 does not give the option of assessing multiple chemicals being released from the gas flares at once to determine whether the combination of chemicals reduce or increase toxicity and extent. The data used as inputs in

SCREEN View 4 were not all from the Uzere gas flare site. It is very difficult to obtain specific data on gas flare releases as oil and gas companies in Nigeria are not transparent with all data.

Fourth, population numbers in Delta state and other parts of Nigeria are a bit controversial as they are sometimes deflated and/or inflated as the last national census was in 2006 and data was not disaggregated at the community-level. Through preliminary research, various population numbers from local agencies, community leaders and community representatives were obtained, and population size of LGAs were provided by the National Bureau of Statistics and the World Bank (2013). Estimates of population size in Uzere and Aviara were extracted from LandScan (ORNL, 2016). We were hoping to obtain a sample size closer to the 90.0 percent confidence level, which would have been approximately 260 women surveyed each in Uzere and Aviara. However, we did not have enough women attend the group survey sessions.

Fifth, due to the study being conducted at the group-level, we did not control for age, which may result in older women in Uzere having a higher rate of arthritic pains and other chronic diseases. Sixth, due to the inability of predicting a severe flood in 2016, we had to use the September 2012 severe flood as an indicator of communities that will be more impacted than others if there is another severe flood in the future. However, these communities are exposed annually to flooding, which still puts them at increased risk. Finally, the design of this research may have introduced selection bias, recall bias, and perceptual/observer bias. To reduce selection bias, we had town hall meetings, sent reminders to women group meetings and advertised in the communities' market area to allow any woman above the age of 18 years to participate in the group surveys. Therefore, women participated in the group survey at will. The self-reported symptoms and diseases and health conditions may be false or not well represented, which may contribute to recall bias. Please note that not all respondents participated in the questions for children since some did not have children of their own or children in their homes. Also, some respondents did not remember whether children had better health during the rainy or dry seasons. We ensured that questions were asked in different ways and findings were cross-validated by a validation meeting in 2017 and secondary sources to reduce recall bias and perceptual/observer bias.

4.9. CONCLUSION

Studies on the health consequences of the oil and gas industry and potential eco-syndemics among women and children in Nigeria are limited. And, in the time of climate variability around the world, where the health of vulnerable populations may be even more compromised, it is crucial to explore in-depth the underlying causes of disease to develop better solutions. In recent years, flooding has intensified in the Niger Delta and across Nigeria with serious consequences on the homes, livelihoods and health of affected populations. There is a tendency to group most communities in the Niger Delta in one because all the communities experience some form of disadvantage due to the oil and gas industry’s presence in the region. However, it is critical to determine whether there are, indeed, any differences during flooding such as NaTech events, to determine health implications of flooding events that damage oil facilities.

This chapter investigated whether health of women and children in oil and non-oil producing communities are impacted in similar ways with recurring and more intense flooding events. We found that with annual flooding and in some instances, severe flooding events, oil-producing communities are still at greater risk than non-oil producing communities in Isoko South LGA. Since the oil industry is the major industrial operation in Uzere, we can conclude that the toxic chemicals emitted from the gas flares and oil spills are the main reasons for higher prevalence of health conditions and diseases. The Niger Delta is a prime example of anthropogenic (oil and gas industry) and natural (flooding) burdens on population health. It is imperative to continue to study the impacts of the oil and gas industry and flooding on vulnerable populations in the Niger Delta.

It will be critical to invest in water treatment for the residents in both communities. The lack of water treatment may be creating greater health hazards for this population, including the development of peptic ulcers. The only people that treated their water in this study were paid employees that worked for the government. Therefore, increasing incomes for women will allow them to invest in water treatment for their families. Health facilities will also need the proper diagnostic equipment, which is sometimes lacking due to finances. This will allow better screening of certain health conditions of interest –asthma, cancer, etc. Healthcare workers need to also be better trained to check for more than the temperature when it is time for vaccinations. They need to check dietary habits and whether the patient had diarrhea in the last few days. This may also need to include more health education among the population to allow parents to ask the right questions during health visits. There also need to be better infrastructure to deal with standing water during the rainy season, which increases the breeding grounds for the Anopheles mosquitoes that transmit malaria.

CHAPTER 5

THE WAY FORWARD – DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

5.1. MAIN CONCLUSIONS

The Niger Delta in Nigeria is endowed with vast natural resources. Since 1975, crude oil reserves in the Niger Delta have accounted for approximately 90.0 percent of Nigeria's export earnings, yet it remains one of the most underdeveloped regions in Nigeria (Watts, 1999, 2005; Douglas et al., 2005; World Bank, 2013). The Niger Delta has experienced many years of conflict due to years of neglect and poverty, which is mostly linked to the oil and gas industry. Communities have protested and put pressure on the oil and gas industry and the Nigerian Government for decades to hold them accountable for the environmental degradation and social and health inequalities in the region (Adeola, 2000; 2001). There are two angles to social and health disparities that are observed in the region: first, coming directly from the oil industry in the form of oil pollution (i.e., oil spills and gas flares) and secondly, an indirect outcome, where the presence of oil and gas industry operations prevent communities from obtaining well-planned infrastructure and quality public services, including health care services, which creates a highly stressed population were health hazards are deepened.

The political ecology of health theoretical framework helps explain these inequalities as it suggests that decisions that transform the natural environment, often produced by Western-controlled political and economic systems, expose certain population groups to unhealthy conditions that transform and spread diseases and ill health (Walker and Bulkeley, 2006; Singer, 2009; King, 2010; Jackson and Neely, 2014). The concepts of syndemics and eco-syndemics evolved within this theoretical framework, which recognize the multi-factorial interactions that create environments that contribute to disease and to re-theorize biomedical and epidemiological models of disease that solely focus on isolated individual threats of health (Singer and Clair, 2003; Baer and Singer, 2009; Jackson and Neely, 2014; Singer, 2013b). In traditional aspects of health, it is theorized that every case of illness has a single underlying cause, a specific and identifiable disease as the source of each illness, and the removal or reduction of the disease producing a return to health (Wade and Halligan, 2004). Syndemic and eco-syndemic research step away from this structure by taking into account all possible causes of diseases, including political, economic, social and environmental conditions.

In the case of the Niger Delta, the oil industry is known to release toxic pollutants through oil spills and gas flares, which have increased health hazards in communities close to their activities (Ana et al., 2009; Gobo et al., 2009). Furthermore, intensive and extensive flooding disasters due to climate variability and poorly planned infrastructural development is an emerging threat that may increase the population's exposure to infectious agents (Kondo et al., 2002; Baer and Singer, 2009) and hazardous substances released when industrial facilities are damaged, also known as NaTech events (Arellano et al., 2003; Ruckart et al., 2008; Cruz and Krausmann, 2009; Sengul et al., 2012; Cruz and Krausmann, 2013). However, there is little knowledge about the compounded impacts of the oil and gas industry and recurring and severe flooding on the health of the most vulnerable populations, which are women and children in the Niger Delta. Women are more vulnerable due to their reproductive abilities and their gender-based roles that involve working outdoors leading to higher exposure of pollutants (Jamieson et al., 2006; Mor and Cardenas, 2010; Singer, 2013a). Children are more vulnerable because their major organs are still developing, and they are in many cases more susceptible to environmental pollutants (Sly and Flack, 2008). Also, children with poor health outcomes in a region is a known indicator of lower levels of economic development and a less healthy population (Reidpath and Allotey, 2003) and it is therefore, critical to address the root causes of poor health in children to ensure better health for the whole community.

This is of critical importance as many African communities believe that the community's well-being takes precedence to individual needs. This is in line with the Africana womanist theoretical perspective, which is a family- and community-centered perspective that dictates that women's needs are only accounted for once the community's and family's needs are addressed (Hudson-Weems, 1993; Oyewumi, 1997; Joyce, 2001; Alexander-Floyd and Simien, 2006; Iromuanya, 2008). Western theoretical perspectives such as feminism and perspectives partly based in Western theories such as African feminism and Black feminism may not fully acknowledge the needs and wants of Africana communities (Hudson-Weems, 1993). Within the political ecology of health, feminist and marxist theoretical perspectives attempt to address health inequalities and incorporate the voices of the marginalized, making it clear that intersectionality, which acknowledges the multiple systems of oppression on certain population groups ranging from racism, classism to sexism, needs to be included (Jackson and Neely, 2014). African feminism and Black feminism are two theoretical perspectives that are borne out of the Feminist Movement but are rooted in the experiences of Africana women. Both of these theoretical perspectives reject white feminism, similar to Africana womanism, because it sees men, including Africana men, as enemies and the experiences of Africana women are not prioritized in the Feminist Movement (Combahee River Collective, 1977; Collins, 1991; Few, 2007; Nkealah, 2016). However, the incorporation of the multiple oppressions that Africana families experience is not enough for Africana womanism as it requires that the historical oppression due to Africana women's racial identity need be addressed first before disentangling the oppression they encounter due to their gender identity. In today's world where Western customs have infiltrated many Africana communities, it may be more appropriate to link Africana womanism to feminism if African feminism and Black feminism are included in the framework when conducting political ecology of health research. This will allow a multitude of Africana perspectives to be included in the development of solutions that Africana communities are experiencing.

In the Niger Delta, as in many African communities, the protection of the environment and biodiversity are critical to their livelihoods and survival. In order to develop effective solutions to reduce environmental and health hazards in the Niger Delta communities, a better understanding of the region's pre-existing vulnerabilities is necessary. The Niger Delta was formed mainly through the fluvial processes and sediment deposition of the Niger River that begins in the Guinean Highlands. This delta has fragile ecosystems and is therefore, quite susceptible to any natural or human-induced changes (Ogri, 2001; Ko and Day, 2004). First, climate variability is quite common in Nigeria since climate and weather patterns began to be monitored in the 20^{th} Century (Uyige and Agho, 2007; Akinsanola and Ogunjobi, 2014). There have been wetter and drier decades and in recent years, a wetter period for coastal southern Nigeria, where the Niger Delta is located (Adefolalu, 1986; Odjugo, 2005; Akinsanola and Ogunjobi, 2014) with increases in heavy rainfall leading to more flooding (Umoh, 2002; Odjugo, 2005). Second, oil extraction in the region has disrupted the soil structure and composition, vegetation, and flora and fauna, increasing the likelihood of more severe floods (Ogri, 2001; Ko and Day 2004; Ana et al, 2009; Federal Government of Nigeria et al. 2013; Amangabara and Obenade 2015). It has also led to the chronic exposure of hazardous releases from oil spills and gas flares into the environment contaminating the soil, water and the air and increasing health risks in many oil-producing Niger Delta communities (UNDP, 2006; Ana et al., 2009; Gobo et al., 2009).

Third, intensive and extensive flooding disasters could also increase the exposure of this population to the hazardous releases from oil spills and gas flares that are already present in the environment (Osuji and Onoake, 2004; Appel, 2005; Dung et al., 2008; Nigerian Ministry of the Environment, 2014; Cruz and Krausmann, 2013; United Nations International Strategy for Disaster Reduction [UNISDR], 2018). Also, if oil and gas industry infrastructure is damaged during flooding disasters, it could result in NaTech events leading to an additional exposure to toxic substances (Arellano et al., 2003; Cruz et al., 2006; Cruz and Krausmann, 2009). Fourth, poorly planned infrastructural development such as highways constructed that block the natural hydrological flow of flood waters and dams built in neighboring countries that are unable to hold enough water during heavy rainfall have also increased flooding hazards in the Niger Delta (Dodman et al., 2009; Federal Government of Nigeria et al. 2013; Amangabara and Obenade 2015). There are also plans to build dams in the upper and middle Niger River Basin, which could potentially increase the intensity of flooding in Niger Delta riverine communities particularly with the projected increases in rainfall in the Guinean Highlands and Cameroon in the mid-century (Sylla et al., 2012; Haensler et al., 2013; Niang et al., 2014). Finally, widespread poverty has been forced on the Niger Delta population largely reducing the population's livelihoods to subsistence farming and fishing and poverty-level incomes (United Nations Development Program [UNDP], 2006; Ogunlela and Muhktar, 2009). These multiple vulnerabilities have put the Niger Delta population in a constant loop of stress as their resilience mechanisms are becoming less effective at managing these burdens. The lenient environmental regulations on the oil and gas industry and the impact of flooding on local livelihoods and community life are potentially leading to a higher prevalence of diseases.

It is therefore critical to examine whether oil-producing communities have different levels of exposure to oil pollution (gas flares) and greater health concerns compared to non-oil producing communities when both are located in flood-prone areas. This dissertation study focused on Uzere (oil producing) and Aviara (non-oil producing) communities in Isoko South LGA in Delta state that are known to be flood-prone and were severely affected by the severe floods of 2012 in Nigeria. Uzere community has two gas flares that emit toxic chemicals and pollutants into the environment. Calculations were made on one of the two gas flares. Five chemicals (benzene, toluene, xylenes, styrene, and ethyl-benzene) were assessed and benzene, styrene and ethyl-benzene are known to be carcinogenic and they have not been studied in depth in the Niger Delta. SCREEN View 4, a dispersion-based model, was used and an extent of 10,000m, which completely encompasses Uzere and Aviara communities, was calculated. However, Aviara community is less impacted due to its distance from the gas flare site. Benzene and ethyl-benzene had the farthest distance reached above exposure limits. Toluene and styrene were only above the exposure limits close to the gas flare site. Xylenes were not above the exposure limits. Previous research in the Niger Delta has shown an increase in cancer rates and illnesses related oil pollution such as leukemia (Omoti et al. 2006), ovarian and testicular cancers in young adults (Abudu and Akinbami, 2016), and higher nervous system birth defects in children born in the Niger Delta compared to other regions of Nigeria (Abbey et al., 2017).

This dissertation study also included a retrospective cross-sectional study with group surveys of 208 women conducted in Uzere and Aviara to identify the differences in self-reported health conditions and diseases. The group survey results were then analyzed in SPSS 24.0. Uzere (oil producing community) had a higher prevalence of certain self-reported health conditions that can be linked to oil pollution as well as flooding compared to Aviara (non-oil producing community). Children in Uzere were more likely to be diagnosed with asthma, have chest pain, and develop rashes compared to Aviara. Interestingly enough, although respiratory illnesses are high in Uzere children, women cited that their children's health is worse during the rainy season compared to the dry season. In some studies, gas flaring during the rainy season reduced the particulates in the air, potentially reducing respiratory symptoms (Gobo et al., 2009). However, worse health outcomes for children during the rainy season could signify the possibility of an exacerbation of health conditions during the rainy season due to being immunocompromised by diseases such as asthma (eco-syndemics). Also, Ruckart et al. (2008) found that during Hurricanes Katrina and Rita in the United States, toxic air releases from industrial facilities were the most common and therefore, there is a possibility that during more than normal flooding events, asthma is exacerbated due to potential toxic air releases from damaged oil facilities in the Niger Delta.

Higher levels of diarrhea, malnutrition, and malaria (not statistically significant) were also found in children in Uzere compared to Aviara. Women in Uzere were more likely to have ulcers compared to Aviara women even though they have similar ways of obtaining their water and are both less likely to treat their water. Furthermore, even though both communities are engaged in farming, Uzere women were approximately 20.0 times more likely to have arthritis compared to women in Aviara. Some studies have shown that exposure to certain chemicals may create an inflammatory response leading to weaknesses in the bones (Meggs, 1993; Guo et al., 1999; Stolt et al., 2005). Women and children in Uzere community are potentially at heightened risk compared to Aviara community because of the increased exposure to hazardous releases from the oil and gas industry. Essentially, the whole community, including men, are more exposed, which increases the vulnerability of this population.

The dissertation study has shown that toxic chemicals that are emitted from gas flares and oil spills are potentially the root causes for the higher prevalence of health conditions and diseases in Niger Delta oil producing communities and to a slightly lesser extent, in non-oil producing communities. Cancer rates in the Niger Delta are on a rise and there are potentially higher rates of nervous system abnormalities, blood disorders, and reproductive health diseases. This dissertation study also identified potential eco-syndemics in the Niger Delta that need to be investigated, including how the intensification of flooding may lead to more exposure of oil and gas pollutants, also known as NaTech events.

5.2. RECOMMENDATIONS

There are various solutions that can be implemented to reduce the impact of oil and gas industry activities and flooding in the region. First, there has been more attention in recent years to reduce gas flaring around the world due to its contribution to greenhouse gasses. The Nigerian Government is mobilizing the private sector towards gas flare capture projects to turn it into liquefied petroleum gas for the benefit of Nigerians (Sweet Crude Reports, 2017). The World Bank (2017) is also accepting proposals to financially support companies with viable solutions to monetizing flared gas. Second, infrastructure that considers the protection of communities from recurring and severe flooding need to be built. Mmom and Aifesehi's (2013) study of 500 households in 10 riverine communities in the Niger Delta identified a few ways that communities are attempting to mitigate the risks from future floods. Half of the respondents raised the building heights and added damp-proofing to their homes, which is a barrier used to ensure water does not enter from the ground into the home/building (Mmom and Aifesehi, 2013). Many homes in Niger Delta rural communities tend to be built using material that disintegrates with prolonged days of flooding such as mud. A little over half of those surveyed said that they used flexible construction materials to deal with future floods (Mmom and Aifesehi, 2013). The International Federation of Red Cross and Red Crescent (IFRC) has worked with flood-prone communities in Kogi state (non-Niger Delta state) to use local resources to build stronger homes for flooding such as wood for frames, concrete for columns and walls, and cement for the foundation and floor (Fogden and Madamidola, 2013). Niger Delta residents have also incorporated mud slopes directly outside of the homes to force flooded waters to move away from the homes (Mmom and Aifesehi, 2013). Other methods used to deal with future floods by those surveyed was to relocate their moveable properties to families not located in flood-prone zones, construction of flood diversion trenches, and changing their farming regime such as planting earlier in the season (Mmom and Aifesehi, 2013).

Third, flood insurance programs need to be developed and implemented. African Risk Capacity (ARC), an African Union specialized agency, was created to improve the capacities of African countries to manage intensive disaster risks as a group creating a pan-African preparedness and response system using modern finance mechanisms (ARC, 2018). This is important since it provides a social safety net to many marginalized and disadvantaged communities who would be unable to rebuild their homes and engage in their climate-sensitive livelihoods in a timely manner after a severe natural disaster (UNISDR, 2018). There should also be the development of community-based flood insurance programs for recurring floods (extensive disasters) in the Niger Delta. Communities should create their own savings mechanisms to enable them to have financial resources for damage caused by recurring floods since the Government will most likely only protect against severe flooding events. Fourth, empowering local governments is a key component to reducing disaster risks (Dodman et al., 2012). Nigeria had begun to decentralize before the structural adjustment programs of the 1980s (Wunsch and Olowu, 1996). In the 1990s, some federal government officials wanted to retain their authority and resources and did not transfer responsibilities to local authorities (Olowu, 1990; Wunsch, 2001). There are still many issues today in local governance in the region and therefore, more support has to be provided to adequately address disaster risks and poverty locally (Winsch, 2001). Finally, the Nigerian Government needs to develop and implement policies that will address damage to industrial facilities, particularly oil and gas facilities, during natural disasters. There is currently no agency tasked to deal with the compounding effects of flooding in oil-producing areas (Ezeigbo and Picard, 2012) including the pre-existing toxic releases via oil spills and gas flares and the potential releases of hazardous substances from damaged oil and gas facilities when flooding occurs. Addressing environmental and health hazards by reducing oil pollution, providing adaptation mechanisms to recurring and severe flooding, and developing and implementing policies that will hold the oil and gas industry accountable for toxic releases will enable communities as a whole across the Niger Delta to improve their standard of living and health outcomes.

APPENDICES

APPENDIX A: GROUP SURVEY.

GROUP SURVEY CONSENT

Introduction

[Note to Enumerator: *Please read this introduction to everyone.*]

Dear Participants:

[Introduce yourself]

You are being asked to participate in this group survey to better understand the health concerns in communities in Delta state. We are particularly interested in learning about your health and children's health during the rainy season and how you are able to cope during that season, especially if there is flooding. You will be asked to answer questions concerning your thoughts, experiences and opinions on the health issues. We will also ask questions ranging from the type of house you live in to your health concerns. The group survey should take no longer than 2 hours. In order to qualify for this study, you must be at least 18 years of age.

Participation in this group survey is completely voluntary and is anonymous. You have the right to say "no." If you agree to participate, you will receive compensation at the end of the survey.

We are very grateful for your assistance and if you do not want to participate at this time, please feel free to let us know now. If you do want to participate, please come forward and provide some details that we will need before beginning the group survey.

GROUP SURVEY QUESTIONS

Enumerator should read the following questions at a slow pace to allow transcribing to take place.

I will read out the questions and **please raise your hand ONLY if it applies to you**.

SECTION 1: Women's Health/ Maternal Health

1.1. Have you been limited in any of the following activities due to health problems? (Raise your hand for all that apply)

a. Walking/ Running
b. Eating
c. Drinking
d. House cleaning/ working
e. Fetching water/ carrying heavy load
f. Other:

1.2. Have you, in some cases, limited in your spending due to your physical health?

a. Yes
b. No

1.3. How often have you had bodily pain and/or discomfort?

a. At least twice a year
b. At least 6 times a year
c. More than 6 times a year
d. Don't remember

1.4. What time of the day do you mostly experience bodily pain and/ or discomfort?

a. Morning
b. Afternoon
c. Evening
d. All day
e. I don't know

1.5. What season of the year have you experienced most bodily pain?

a. Rainy
b. Dry
c. Both

1.6. Was your health better during this year's rainy season or last year's rainy season?

a. This year's rainy season
b. Last year's rainy season
c. Don't remember

1.7.Was your health better during this year's dry season or last year's dry season?

a. This year's dry season
b. Last year's dry season
c. Don't remember

1.8.Are there any health symptoms that you possessed in the past 4 months?

a. Chest pain/ Difficulty breathing/ Asthma
b. Arthritis
c. Malaria
d. Diarrhea
e. Stomach issues
f. Constipation
g. Vomiting
h. Fever
i. Typhoid
j. Rash
k. Ulcer
l. Other:

1.9.Did any of these symptoms come one after the other?

a. Yes
b. No

1.10. If yes, which symptoms came first and which came second?
Please specify:

1.11. What symptom of yours are you most worried about?
Please specify:

1.12. Do you have any children under the age of 12?

a. Yes
b. No
c. Currently pregnant with first child

1.13. If you <u>do not have children under the age of 12</u>, does anyone in your household have children?

a. Yes
b. No

1.14. What health services did you or the woman receive when visiting a clinic during your pregnancy? (Raise your hand for all that apply)

a. Physical examination
b. Gynecological exam

c. Ultrasound
d. HIV/STD Testing
e. Blood tests
f. Nutritional supplements/Eating plan
g. Tetanus vaccine
h. No hospital

1.15. For the <u>last born</u>, did you or the woman in your household give birth in the dry or rainy season?

a. Dry
b. Rainy

1.16. For those who gave birth during the rainy season, did you have any complications during your pregnancy?

a. Yes
b. No

1.17. If yes, what were the complications for those who gave birth during the rainy season?

Please specify:

1.18. For those who gave birth during the dry season, did you have any complications during your pregnancy?

a. Yes
b. No

1.19. If yes, what were the complications for those who gave birth during the dry season?

Please specify:

1.20. Did any of you or a woman in the household ever have malaria during pregnancy?

a. Yes
b. No

1.21. Did you have any other health issues during your pregnancy? (Raise your hand for all that apply)

a. Blood issues
b. Difficulty breathing
c. Stomach issues
d. Diarrhea
e. Constipation
f. Vomiting

g. Fever
h. Typhoid
i. Other (specify)

1.22. What were you most worried about while you were pregnant?

SECTION 2: Vaccinations and Child Health

2.1. Were you vaccinated in primary school?
a. Yes
b. No

2.2. Were you vaccinated during pregnancy?
a. Yes
b. No
c. Don't remember

2.3. Are the children in your household vaccinated?
a. Yes
b. No

2.4. Does anyone here remember the names of the vaccines given? If so, please let us know.

2.5. Who primarily in all of your experiences vaccinated the children?
a. Doctor/ Nurse
b. Health workers
c. Other (specify)
d. Don't remember

2.6. Did you have to pay for your child's vaccination?
a. Yes
b. No

2.7. Do you remember if they were ever sick when they were vaccinated? Examples: Diarrhea/Malaria.
a. Yes, they were sick
b. No, they were not sick

2.8. If they were sick when vaccinated, what did they have?

2.9. Have any of your children been limited in any of the following activities due to health problems? (Raise your hand for all that apply)

a. Playing sports such as soccer/ running
b. Eating
c. Drinking
d. House cleaning
e. Fetching water
f. Other:

2.10. How often has your child had bodily pain and/or discomfort?

a. At least twice a year
b. At least 6 times a year
c. More than 6 times a year
d. Don't remember

2.11. During this year's rainy season, how would you rate your child's health compared to last year's rainy season?

a. Worse
b. Better
c. Don't remember

2.12. Was your child's health better during the dry or rainy season this year?

a. Dry season
b. Rainy season
c. Don't remember

2.13. Do you know any health symptoms/ problems that your child possessed in the past 4 months? (Raise your hand for all that apply)

a. Chest pain/ Difficulty breathing
b. Malaria
c. Diarrhea
d. Stomach issues
e. Constipation
f. Vomiting
g. Fever
h. Typhoid
i. Rash
j. Other:

2.14. Did any of these symptoms come one after the other?

a. Yes
b. No
c. I don't remember

2.15. For those that answered yes, which symptoms came first and which came second?

2.16. Has your child been diagnosed with asthma by a doctor?

a. Yes
b. No
c. I don't know

2.17. How much protein (fish, meat, eggs, etc) did your last born have per day when he or she was under 12 years old? (show picture of 20 grams of fish)

a. Quarter of a piece (5 grams)
b. Half of a piece (10 grams)
c. One piece (20 grams)
d. More than one piece (21 grams or more)
e. Don't remember

2.18. Did you breastfeed your last born?

a. Yes
b. No

2.19. After you stopped breastfeeding, did you start giving your child protein (fish, chicken, meat, eggs, etc) within 2 weeks?

a. Yes
b. No

2.20. If you said yes to 2.19, how much protein did you provide on average between 6 months to age 5?

a. 2 times a week
b. 4 times a week
c. Once a day

2.21. Does your last born get vitamin A supplementation when you take them for vaccinations?

a. Yes
b. No
c. Don't remember

2.22. What symptom or health problems of your child/ren worries you most?
Specify:

SECTION 3: Housing Characteristics

3.1. Do you or your spouse own the house or compound you live in?

a. Yes
b. No

3.2. Which of the following type of housing applies to you? (one answer only)

a. Single family house (rented or owned)
b. Multi-family compound
c. Workplace quarters
d. Apartment
e. Tent
f. Other (Specify):

3.3. What is the main construction material used for the outer walls of your house? (one answer only)

a. Cement blocks
b. Mud/ sand
c. Bricks
d. Metal sheets
e. Wood/ bamboo
f. Other (Specify):

3.4. What is the main roofing material of your house? (one answer only)

a. Zinc/Iron sheets
b. Concrete
c. Roofing tiles
d. Grass
e. Plastic sheets
f. Other (Specify):

3.5. What is the main construction material on the floor of the house? (one answer only)

a. Cement
b. Smoothed mud/ Sand
c. Wood
d. Tiles
e. Other (Specify):

3.6. Which type of lighting does your house mainly use? (one answer only)

a. Electricity
b. Generator
c. Kerosene/lantern/candles/ Torch
d. Solar
e. Other (Specify):

3.7.What is the <u>main</u> source of fuel for household cooking? (one answer only)

a. Firewood
b. Charcoal
c. Gas stove
d. Electric stove
e. Kerosene stove
f. Solar energy
g. Paraffin
h. Crop residue/sawn dust
i. Animal dung
j. Other (Specify):

3.8.If you use firewood or charcoal, do you mainly cook indoors or outdoors?

a. Indoors
b. Outdoors

3.9.What is your <u>household's primary source of drinking water</u>? (one answer only)

a. Borehole
b. Protected well (Covered)
c. Unprotected well (Open)
d. Tap in house
e. Rainwater
f. Tap in yard/plot/compound
g. Surface water (River, Lake, Stream, Pond)
h. Communal tap/water kiosk
i. Small scale vendor
j. Neighbors tap
k. Tap or Kiosks in another community
l. Other (Specify):

3.10. If you use a borehole or a well for drinking water, do you treat the water before drinking?

a. Yes
b. No

<u>SECTION 4: Socio-Economic Status (SES)</u>

4.1. What is your household's primary source of income? (one answer only)

a. Paid employment/wages
b. Sale of crops and other farm produce
c. Non-farm household/individual enterprises/business
d. Rent from houses/lands/animals/equipment you own

e. Sale of own livestock/fish/milk
f. Sale of wild animals/fruits/yam and other vegetables
g. Sale of own produced firewood/charcoal
h. Remittances from relatives outside
i. Other (Specify):

4.2.Which of the following assets <u>do you or your household own</u> or have? (Raise your hand for all that apply)

a. Radio
b. Telephone
c. Refrigerator
d. Electric generator
e. Bicycle
f. Livestock
g. Motorcycle
h. Flush toilet
i. Car
j. Piped water
k. Cell phone
l. Electric stove
m. Keke (tri-cycle)
n. Savings account
o. Houses for renting
p. Television set/TV

4.3.Has anyone in <u>your household</u> used a credit scheme (loan) before?

a. Yes
b. No
c. I don't know

4.4.If yes, what was the credit mainly for? (Raise your hand for all that apply to you)

a. Fertilizer
b. Buy food
c. Start a private business
d. Agricultural seed
e. Buy clothes
f. Repayment of debt
g. Child's education
h. Medical expenses
i. Social obligation (wedding, funeral, other)
j. Other (Specify):

4.5.What is your highest education level?

a. No education

b. Primary
c. Secondary
d. University and more

APPENDIX B: SCREEN VIEW 4 RESULTS

Table B-1: SCREEN View 4 Results of Benzene and Toluene Released by the Uzere Flare, Delta state.

	Benzene*1			Toluene*2		
Distance (m)	(ppm/hour)	(ppm/8-hour day)	(ppm/24-hour day)	(ppm/hour)	(ppm/8-hour day)	(ppm/24-hour day)
100	26.85	214.80	644.40	4.20	33.56	100.68
200	15.89	127.12	381.36	2.48	19.86	59.57
300	10.16	81.28	243.84	1.59	12.70	38.11
400	6.87	54.95	164.86	1.07	8.58	25.75
500	4.93	39.47	118.42	0.77	6.17	18.50
600	4.49	35.90	107.69	0.70	5.61	16.82
700	4.48	35.82	107.45	0.70	5.60	16.79
800	4.28	34.23	102.70	0.67	5.35	16.04
900	4.04	32.30	96.89	0.63	5.04	15.13
1,000	3.78	30.24	90.72	0.59	4.72	14.17
1,100	3.52	28.18	84.55	0.55	4.40	13.21

Table B-1 (cont'd)

1,200	3.28	26.26	78.79	0.51	4.10	12.31
1,300	3.06	24.48	73.44	0.48	3.82	11.47
1,400	2.86	22.85	68.54	0.45	3.57	10.71
1,500	2.67	21.36	64.08	0.42	3.34	10.01
1,600	2.50	20.00	60.00	0.39	3.12	9.37
1,700	2.35	18.76	56.28	0.37	2.93	8.79
1,800	2.20	17.63	52.90	0.34	2.76	8.27
1,900	2.08	16.60	49.80	0.32	2.59	7.78
2,000	1.96	15.66	46.99	0.31	2.45	7.34
2,100	1.85	14.82	44.47	0.29	2.32	6.95
2,200	1.76	14.06	42.19	0.27	2.20	6.59
2,300	1.67	13.36	40.08	0.26	2.09	6.26
2,400	1.59	12.71	38.14	0.25	1.99	5.96
2,500	1.51	12.11	36.34	0.24	1.89	5.68
2,600	1.45	11.56	34.68	0.23	1.81	5.42
2,700	1.38	11.05	33.14	0.22	1.73	5.18

Table B-1 (cont'd)

2,800	1.32	10.58	31.73	0.21	1.65	4.96
2,900	1.27	10.14	30.41	0.20	1.58	4.75
3,000	1.22	9.72	29.16	0.19	1.52	4.56
3,500	1.01	8.09	24.26	0.16	1.26	3.79
4,000	0.86	6.88	20.65	0.13	1.08	3.23
4,500	0.74	5.96	17.87	0.12	0.93	2.79
5,000	0.65	5.23	15.68	0.10	0.82	2.45
5,500	0.58	4.64	13.92	0.09	0.73	2.18
6,000	0.52	4.16	12.48	0.08	0.65	1.95
6,500	0.47	3.76	11.28	0.07	0.59	1.76
7,000	0.43	3.42	10.27	0.07	0.53	1.60
7,500	0.39	3.14	9.43	0.06	0.49	1.47
8,000	0.36	2.90	8.71	0.06	0.45	1.36
8,500	0.34	2.69	8.08	0.05	0.42	1.26
9,000	0.31	2.51	7.52	0.05	0.39	1.18
9,500	0.29	2.34	7.03	0.05	0.37	1.10

Table B-1 (cont'd)

10,000	0.27	2.20	6.60	0.04	0.34	1.03

*1 Cal/OSHA PEL for workers is 1.0 ppm/8-hour day; ATSDR Chronic Minimal Risk Level (365 days or more) for Benzene is 0.003 ppm/day.
*2 Cal/OSHA PEL for workers is 10.0 ppm/8-hour day; ATSDR Chronic Minimal Risk Level (365 days or more) for Toluene is 1.0 ppm/day.

Table B-2: SCREEN View 4 Results of Xylenes, Styrene, and Ethyl-Benzene Released by the Uzere Flare, Delta state.

	Xylenes*3			Styrene*4			Ethyl-Benzene*5		
Distance (m)	(ppm/hour)	(ppm/8-hour day)	(ppm/24-hour day)	(ppm/hour)	(ppm/8-hour day)	(ppm/24-hour day)	(ppm/hour)	(ppm/8-hour day)	(ppm/24-hour day)
100	6.87	54.95	164.86	17.40	139.20	417.60	18.35	146.80	440.40
200	4.06	32.51	97.54	10.30	82.40	247.20	10.85	86.80	260.40
300	2.60	20.80	62.40	6.59	52.70	158.09	6.95	55.56	166.68
400	1.76	14.06	42.17	4.45	35.61	106.82	4.69	37.54	112.63
500	1.26	10.10	30.29	3.20	25.58	76.75	3.37	26.97	80.90
600	1.15	9.18	27.55	2.91	23.26	69.79	3.07	24.53	73.58
700	1.15	9.16	27.48	2.90	23.21	69.62	3.06	24.47	73.42
800	1.10	8.76	26.28	2.77	22.18	66.55	2.92	23.39	70.18
900	1.03	8.26	24.79	2.62	20.93	62.78	2.76	22.06	66.19
1,000	0.97	7.74	23.21	2.45	19.60	58.80	2.58	20.66	61.99
1,100	0.90	7.21	21.63	2.28	18.26	54.79	2.41	19.26	57.77
1,200	0.84	6.72	20.15	2.13	17.02	51.05	2.24	17.94	53.83
1,300	0.78	6.26	18.79	1.98	15.86	47.59	2.09	16.73	50.18
1,400	0.73	5.84	17.53	1.85	14.81	44.42	1.95	15.62	46.85

Table B-2 (cont'd)

1,500	0.68	5.46	16.39	1.73	13.84	41.52	1.82	14.59	43.78
1,600	0.64	5.12	15.35	1.62	12.96	38.88	1.71	13.66	40.99
1,700	0.60	4.80	14.40	1.52	12.16	36.48	1.60	12.82	38.45
1,800	0.56	4.51	13.53	1.43	11.42	34.27	1.51	12.05	36.14
1,900	0.53	4.25	12.74	1.35	10.76	32.28	1.42	11.34	34.03
2,000	0.50	4.01	12.02	1.27	10.15	30.46	1.34	10.70	32.11
2,100	0.47	3.79	11.38	1.20	9.61	28.82	1.27	10.13	30.38
2,200	0.45	3.60	10.79	1.14	9.11	27.34	1.20	9.61	28.82
2,300	0.43	3.42	10.25	1.08	8.66	25.97	1.14	9.13	27.38
2,400	0.41	3.25	9.75	1.03	8.24	24.72	1.09	8.69	26.06
2,500	0.39	3.10	9.30	0.98	7.85	23.55	1.04	8.28	24.84
2,600	0.37	2.96	8.87	0.94	7.49	22.48	0.99	7.90	23.70
2,700	0.35	2.83	8.48	0.90	7.16	21.49	0.94	7.55	22.65
2,800	0.34	2.71	8.12	0.86	6.85	20.56	0.90	7.23	21.68
2,900	0.32	2.59	7.78	0.82	6.57	19.70	0.87	6.92	20.77
3,000	0.31	2.49	7.46	0.79	6.30	18.90	0.83	6.64	19.93

Table B-2 (cont'd)

3,500	0.26	2.07	6.21	0.66	5.24	15.73	0.69	5.53	16.59
4,000	0.22	1.76	5.28	0.56	4.46	13.38	0.59	4.70	14.11
4,500	0.19	1.52	4.57	0.48	3.86	11.58	0.51	4.07	12.21
5,000	0.17	1.34	4.01	0.42	3.39	10.16	0.45	3.57	10.72
5,500	0.15	1.19	3.56	0.38	3.01	9.02	0.40	3.17	9.51
6,000	0.13	1.06	3.19	0.34	2.70	8.09	0.36	2.84	8.53
6,500	0.12	0.96	2.88	0.30	2.44	7.31	0.32	2.57	7.71
7,000	0.11	0.88	2.63	0.28	2.22	6.66	0.29	2.34	7.02
7,500	0.10	0.80	2.41	0.25	2.04	6.11	0.27	2.15	6.44
8,000	0.09	0.74	2.23	0.24	1.88	5.64	0.25	1.98	5.95
8,500	0.09	0.69	2.07	0.22	1.74	5.23	0.23	1.84	5.52
9,000	0.08	0.64	1.92	0.20	1.62	4.87	0.21	1.71	5.14
9,500	0.07	0.60	1.80	0.19	1.52	4.56	0.20	1.60	4.80
10,000	0.07	0.56	1.69	0.18	1.42	4.27	0.19	1.50	4.51

*3 Cal/OSHA PEL for workers is 100.0 ppm/8-hour day; ATSDR Chronic Minimal Risk Level (365 days or more) for Xylenes is .05 ppm/day.
*4 Cal/OSHA PEL for workers is 50.0 ppm/8-hour day; ATSDR Chronic Minimal Risk Level (365 days or more) for Styrene is .02 ppm/day.
*5 Cal/OSHA PEL for workers is 5.0 ppm/8-hour day; ATSDR Chronic Minimal Risk Level (365 days or more) for Ethyl-Benzene is .06 ppm/day.

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