THE POTENTIAL IMPACTS OF OIL AND GAS EXPLORATION AND PRODUCTION ON THE COASTAL ZONE OF GHANA

An Ecosystem Services Approach

George Amoasah

MSc Thesis in Environmental Sciences

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Supervised by: Dr. Lars Hein

Environmental Systems Analysis

WAGENINGEN UNIVERSITEIT
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PREFACE

This study examines and analyzes the potential impacts of Ghana's oil and gas exploration and production on its coastal ecosystems and coastal communities. It brings to bear both the environmental impacts and other related socio-economic consequences on the coastal dwellers. Also, it analyzes the nation's legislation ability to cope with the impacts from the oil and gas exploration. My interest in environmental issues started from my teenage when I became curious about the consequences of mining pollution in my native town, Obuasi. Over the years, this town had made Ghana the second highest gold producing country in Africa and till date the country is second only to South Africa on the continent. In the late 1970s, environmental issues were not on Ghana's priority agenda. As such, many environmental issues were taken for granted and this situation resulted in many negative environmental consequences on the local communities. In Obuasi, at first the company's long chimneys released daily huge quantities of aerosols into the atmosphere. This situation had resulted in a continued downpour of acid rain over the town. Meanwhile, many inhabitants depended on this source of water for household chores and even for drinking. I remember on several occasions, I had to fetch rainwater only to realize large quantities of blackish substances settled beneath the collection pan. The greatest of impact was probably felt by the communities closed to the chimneys or were subject to a continued battle with the smoke due to the atmospheric wind direction. With time most inhabitants of these communities developed strange skin colors with strange patterns and spots. But this was not just the end of their calamity. Acidification as a result of the mining activities destroyed many fertile and agricultural lands thereby denying them of their daily livelihood.

Increasingly, it became clear that the environmental situation of this and other mining towns had to improve. But the possibility to study environmental sciences was limited in Ghana. So upon completion of my Bsc agricultural program, I pursued the opportunity to accomplish the MSc in environmental science program of Wageningen University. This time, I decided to focus on new projects because as the saying goes, 'prevention is better than cure'. Ghana is currently less experienced in managing the impacts of oil and gas development and with this new oil and gas discovery the country faces many challenges. If appropriate action is not taken in this era of environmental awareness, then posterity may never forgive this present generation. For this reason, I decided to undertake this study.

I must admit that this study would not have been possible without the assistance of many people whose contributions have brought me this far. My foremost appreciation goes to the Dutch government for granting me the NUFFIC scholarship to study in the Netherlands. My next appreciation goes to my thesis supervisor, Lars Hein, of the Environmental Systems Analysis group of Wageningen University for his constructive criticism and painstakingly supervising this tedious work. I also want to thank Mr. Andre van Amstel, my study adviser, for being there when most needed. Also, my appreciations to the entire staff of the Environmental System Analysis group for making this place a home for me. Many thanks are due to Prosper Antwi

Boasiako for getting some relevant documents from the Environmental Protection Agency of Ghana. Finally, my appreciation goes to my family Florence, Catherine and Gordon for their support and encouragement during this period of solitary life.

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SUMMARY

In 2007, Ghana discovered oil in commercial quantities in the southern coast of Gulf of Guinea. It is generally believed that such a discovery would generate the needed revenue to turn the nation's economic fortunes around. But, such explorations are always associated with massive environmental and socio-economic problems that could even be more costly. Unfortunately in Ghana's situation, the economic benefits seem to have been prioritized over environmental and socio-economic considerations. Meanwhile, Ghana is inexperienced in such an industry and as such lacks the capacity to effectively manage the associated impacts. It is worrying that the region where the project is currently taking place is considered a storehouse of Ghana's biodiversity. Moreover, the region has become a major producer of Ghana's domestic foodstuff, cash crops and also hosts a number of rich natural ecosystems. In view of this, it becomes more necessary that the impacts of oil and gas activities on these resources and the coastal dwellers be assessed in order to make appropriate recommendations to manage these impacts.

The objective of this study is to analyze the potential impacts of oil and gas exploration and production on the coastal zone of Ghana, and to propose recommendations for managing the associated environmental and socio-economic impacts.

The study is based on literature studies with secondary data from the field of environmental, ecological and social sciences. Interviews were conducted among experts and stakeholders of the project for their knowledge and opinion. The impacts are categorized into first order, second order and third order impacts. The analyses are made based on the guidelines of The International Petroleum Industry Environmental Conservation Association (IPIECA) and the United Nations Environmental Program (UNEP). Also, three main aspects of Ghana's legislation are analyzed. These are (1) adequacy of emission standards in Ghana (2) applicability of these emission standards to the oil and gas industry and (3) enforcement of legislation.

There are various kinds of pollutants or pressures through the prospecting phase, the exploration and the exploitation phase. For example, the discharges of drill fluids and cuttings have enormous consequences on the coastal ecosystems and biodiversity. However, the severity of pollutants depends on a number of factors that include the phase of exploration and/or production, the size of the project and the sensitivity of the recipient ecosystems and biodiversity. Noise is considered a worry because the waters of Cape Three Point are part of the migratory route for many cetaceans. Noise could trigger a route diversion or a complete avoidance of the area and, since the presence of the cetaceans could provide an opportunity for tourism development, this has economic implications. There are also socio-economic challenges, which could trigger conflicts between the oil and gas companies and local stakeholders. These include the denial of local fishermen's access to the rig and other operational areas. Also, potentially there can be a sudden increase in population in the region, which can lead to prevalence of diseases, drug addiction, and social tensions (e.g. pressures on schools, hospitals

and other recreational facilities). Finally, natural vegetation will be converted to construction sites to provide enough facilities to meet the demands of the growing local population.

This thesis shows that Ghana currently has no air emission standards despite the existence of guidelines for ambient air quality and effluent discharges. The ambient guidelines do not state at what distance, reference to the point of emissions, measurements must be taken as ambient. Also, the guidelines do not distinguish for on-site and off-site standards. Therefore, the guidelines are inadequate to cope with the pressures from the oil and gas development. Moreover, the monitoring and enforcement of environmental legislation in Ghana have inadequate resources, capacities and lack of political will. This situation has led to implementation gaps of Environmental Impact Assessments, which are mostly conducted halfway through the life cycle of most projects.

Short-term and long-term recommendations are provided. The short-term measures include the need to establish a detailed baseline data on wildlife availability within the project area. Such information could help in impact assessments and cost-benefit analysis. Also, the data could help in future investigations. To assess the real impact on the fishery industry, there is also a need to monitor reductions in fish catch volumes before, during and after a project. All the environmental data should be made public. This should be legally binding to all the oil and gas exploring companies. Finally, in order to minimize noise, there should be limits of flying heights for helicopters especially over the reserved areas and other estuaries.

For long-term measures, it is recommended that the various environmental non-governmental organizations (eNGOs) in Ghana be strengthened to undertake their own investigations on-site. This will help to scrutinize any misdeeds of the oil and gas companies and the EPA officials. Also, the traditional councils in the impacted areas should be part of the monitoring and reporting on the effectiveness of the Environmental Management Plans. Moreover, the governments of the West African marine and coastal eco-region could adopt the concept of a comprehensive regional convention for offshore oil development. This convention should reflect the specific needs of the region and the vulnerability of the local ecosystem. Involving a large range of stakeholders in, for example, citizen councils will be critical to establish adequate regional standards. Furthermore, in order to minimize the impacts of job losses and poverty as a result of reduced fishing activities, there is the need for oil and gas companies to sign social responsibility agreements with their catchment communities. This may involve an establishment of inland aquaculture and other income generation activities to get these people employed. The establishment of a citizen advisory council conforms to an international recommendation that governments and oil industries actively involve major stakeholders in order to deal with complex environmental issues. The stakeholders may include fishermen, tourism operators, scientists and conservationists. Such a practice in Ghana can avoid a lot of mistakes that have been made in the past particularly in most oil rich African countries. Finally, as a mean to avoid long-term transboundary pollution problems with neighboring countries, there is the need to initiate the process of establishing pollution deposition models. This is important in view of the upsurge in

oil and gas exploration activities within the Gulf of Guinea. Currently, there are on-going oil and gas exploration activities in the coast of Cote Dívoire, Nigeria, Ghana, Gabon and Angola. This increased exploration could trigger a massive air pollution problem within the region.

1 INTRODUCTION

1.1 Background

1.1.1 The setting

Oil and gas exploration and production are associated with many environmental and socio-economic impacts (Baptiste and Nordenstam, 2009). Despite this, many nations throughout the world would still cherish to discover oil and gas within their territories. This is due to the fact that the availability of such natural resources is seen as a point of economic transformation and in fact can determine the development fortunes of such nations. With the world's population estimated to increase from the current 6 billion to about 9 billion in 2050 (medium population scenario; UN, 2003), it is logical that the world's energy level increases to meet the demands or at least be reliable in supply. A report by the Energy Information Administration (EIA, 2009) estimates from their reference scenario that with the world's current laws and policies remaining unchanged for the projection period, 'the world marketed energy consumption is projected to grow by 44 percent over the 2006 to 2030 period. Total world energy use rises from 472 quadrillion British thermal units (Btu) in 2006 to 552 quadrillion Btu in 2015 and then to 678 quadrillion Btu in 2030'. The EIA report indicates that the most rapid growth in energy demand is expected to come from nations outside the Organization for Economic Cooperation and Development (non-OECD nations). Furthermore, liquid fuel and other petroleum are expected to remain the world's dominant energy.

Already, nations have relied on uninterrupted supply of oil and gas over the years to meet their energy needs and the commodities still remain critical especially for industrial growth. Unfortunately, in spite of their importance not all nations are abounding in these products hence the dependence on external sources. Meanwhile, the sources of supply have considerably become volatile with time partly because of the very characteristic of the products; non-renewability and also political instability at most points of production. Such a situation threatens to put the guarantee of constant supplies in limbo. Consequently, the trend has led to many states seeking alternative means to ensure energy security. Likewise, businesses in oil and gas industry have responded to the challenge by revising their operational directions. In most cases, attention has been shifted to explore the unexplored and emerging countries where there is relatively a congenial political atmosphere to enhance operations. For most developing countries where oil and gas exploration and production activities are currently taking place, desperation for economic success is usually the driving force behind such operations. The problem here is that most of these countries are inexperienced in the oil and gas industry and usually their decisions are mainly based on economic transformation with little consideration for environmental and social implications.

Ghana, a West African country, is among the few African nations to have recently discovered oil and natural gas in commercial quantities. The country has till now been relying on external

supply of crude oil and gas to meet its domestic energy requirement. Energy situation in the country is currently unreliable due to heavy investment involved in oil importation, which the country can hardly afford. The country's oil import bill for the first quarter of 2008 and 2009 stood at US$643.86 million and US$241.84 million respectively (Bank of Ghana, 2009). Considering the huge spending on oil importation, the oil and gas discovery is seen as a turning point to economic prosperity. But already, stakes are high on political and economic platforms and such an interest from these actors is likely to lead to prioritization of economic consideration over environmental and socio-cultural aspects. According to De Groot (2006:182), on assessing land use conflict in Dnestr delta, Ukraine, 'economic (especially monetary) information plays an important role and tends to dominate the decision-making at the expense of ecological and socio-cultural values'. Often the longer-term consequences of chronic disruptions of the environment are much less readily evaluated, so are not usually factored in the decision making (Carney, 1987) .

A major challenge in oil and gas exploration and production is that the ecological significance of long-term chronic exposures to low-level releases of many chemicals associated with hydrocarbon production activities is largely unknown (NRC 1985; Boesch et al. 1987; Capuzzo 1987). This may be due to the fact that these low level chemicals do not immediately induce environmental catastrophes to the magnitude of oil spillage. Meanwhile, it is apparent that a prolonged accumulation can induce a substantial ecological change of variable scales (Gray et al. 1990; Lissner et al. 1991; Osenberg et al. 1992; Olsgard and Gray 1995). In view of this, it becomes conspicuous that neglecting the immediate and long-term environmental impacts of Ghana's oil and gas exploration and production activities will have a detrimental effect on the surrounding biodiversity and ecosystem. Previous studies have established that in projects where environmental impacts and management are ignored or poorly considered, the expected economic gains in the long term become unproductive or counter productive and sometimes elusive (Balmford et al., 2002; Barbier and Thompson, 1998).

In 2007, Tullow Oil, a United Kingdom based company, involved in the oil exploration in Ghana put the initial quantity of oil in one of its licenced fields, deep waters, at about 600million barrels (Mining Exploration News, 2007). The company estimates reserves at its fields as much as 1.8 billion barrels (GBN, 2009). Currently, many explorations are taking place at various locations throughout the country but so far The West Cape Three Points, the Shallow water Tano and the Deep water sites have shown greater potential for commercial production which is expected to commence in 2010. Obviously, the need to examine and analyze the potential impacts of these exploration and production activities becomes indispensable. Potential impacts usually refer to the likely effects, both positive and negative, on the quality and quantity of biotic and abiotic factors of the physical environment; this includes the ecosystem and biodiversity. However, for this study, the emphasis is on the negative effects of the oil and gas exploration and production activities on the coastal ecosystem and the scope is widened to include relevant socio-economic and cultural aspects of the coastal society. The term coastal zone is used as defined in the

Millennium Ecosystem Assessment: the interface between ocean and land, extending seawards to about the middle of the continental shelf and inland to include all areas strongly influenced by the proximity to the ocean. The boundary limits involve area between 50 meters below the mean sea level and 50 meters above the high tide level from shore. It includes coral reefs, intertidal zones, estuaries, coastal aquaculture, and seagrass communities (Millennium Ecosystem Assessment, 2003:54).

It is worth mentioning that some studies have already been done on the environmental impact of offshore oil and gas exploration. For instance, Baptiste and Nordenstam, (2009) in their study on the Caribbean coast noticed that oil and gas development generates socio-ecological consequences for coastal ecosystems. According to Kotchen and Burger (2007), the potential environmental impact of oil exploration may arise from two principal sources: vehicular travel as part of seismic analyses, and infrastructure for extracting and transporting oil. Ghisel (1997) observed that extraction of fossil fuels from offshore increased dramatically over the last 50 years becoming the most exploitative activity depleting the mineral resources in aquatic ecosystem. The corresponding increment of offshore platforms from such exploration and production activities led Terlizzi A. et al (2008) to analyze the effects of gas platforms on soft-bottom macro-fauna assemblages in the North Ionian Sea and showed that idiosyncratic patterns of assemblage change with increasing distance from the platforms. However, as Kingston (1987) noticed, Environmental Assessments of offshore platform impact have been mostly based on soft-bottom macro-fauna assemblages. Meanwhile, 'to analyze trade-offs between various land use options and the involved ecological, economic and socio-cultural values, analytical valuation procedures must be combined with stakeholder participation techniques' (De Groot, 2006:182). Unfortunately, the stakeholder involvement has often been marginalized and in Africa where the oil drilling activities are booming, decisions are often made without any exhaustible effort to include inputs or views of those whose livelihoods stand to be negatively impacted by the oil and gas activities. Such development has resulted in most cases conflicts and political instability especially in developing countries. For example, in the northern Tanzania a commercial mining operation that failed to involve local and artisan miners in design and benefit sharing was faced with years of conflicts with neighboring miners and high recurrent cost for security (Mwalyosi and Hughes, 1998). Considering the associated environmental impacts of oil and gas exploration, it is apparent that a workable environmental regulation is critical to control or minimize the environmental impacts.

Problem Statement

The western region of Ghana is where the oil and gas are being explored. The region is particularly famous for being the most natural resources endowed area in the country. The region is endowed with natural vegetations which are highly rich in biodiversity. It is the largest producer of cocoa, rubber, coconut, and a major producer of oil palm in the country. Minerals including gold, bauxite, iron, diamonds and manganese are either being exploited or are potentially exploitable. The region falls within the high forest zone reserve in Ghana of which

Ankassa and Nini Suhien National Parks are located 130km west of Takoradi and closer to the La Cote D'voire border. It is a home of evergreen elephants, Diana monkey and Bongo as well as the legendary bamboo canopy. This is an area designated as an international biosphere reserve (Ghana Government, 2009). In view of such importance of the region, it is feared that uncontrolled oil and gas exploration and their associated activities could impact negatively on the surrounding terrestrial and aquatic ecosystem and biodiversity. Already, NGOs and the public have expressed concern over lack of social and environmental impacts assessment prior to the commencement of the project. Moreover, some fishermen have also expressed their dissatisfaction for denying them access to the project area and also for failure on the part of the drilling companies to engage them in discussions prior to their activities (GBC, 2008). Given that Ghana has a limited experience in managing oil resources; institutions are not well established to effectively manage the associated environmental impacts. Meanwhile, it is apparent that such a project comes with a huge environmental impact which if not well managed could cost the nation more than the benefits derived. In extreme situations of improper environmental impact assessment and management, conflicts could be inevitable. Already, Ghana's gold mining industries particularly those in Obuasi and Tarkwa (also in the western region) have witnessed a prolonged period of conflict with the surrounding communities. Most of these conflicts are attributed to the fact that the environment is destroyed whilst the benefits from these mines are not equitably distributed. This situation has resulted in some youths from these mining communities resorting to 'galamsey' (illegal mining) operations, which sometimes extend into the concession fields of the mines. Given such problems, it becomes more important for the oil and gas industry to do the right thing from the onset in order to avoid or at least minimize any future catastrophes.

The structure of this thesis is as follows: Chapter 2 provides the objective for conducting this study and is followed by the research questions that must be answered to satisfy the objective. A detailed explanation is given as to why each formulated research question is relevant to the study as well as the possible issues to be considered under each question.

In Chapter 3, the general approach, scope, study area and methodology are described. The approach is based on the ecosystem services: provisioning, regulating and cultural services. What the study covers and uncovers are discussed in the scope and it presents an argument for considering biodiversity as part of ecosystem. Explicit method for answering each research question is discussed in details and it includes an explanation as to why the three ecosystem services approach is preferred over the four proposed by the Millennium Ecosystem assessments.

In Chapter 4, the results of the study are presented and analyzed. The chapter starts with an overview of oil and gas exploration and production activities. The impacts are then categorized into: first order, second order, and third order; and exploration activities at each phase are presented. The current legislation frameworks in Ghana to cope with the impacts are reviewed. Here, two analyses are done: (a) how the pollutants/pressures, associated with each order, impact on the coastal ecosystems and local communities; and (b) how Ghana's legislation,

environmental standards and guidelines are able to cope with the impacts. The chapter ends with recommendations, both short-term and long-term, to help curb the impacts.

In Chapter 5, uncertainties and how they were dealt with are discussed. Also, the main conclusions from this study are presented. Finally, recommendations for further studies are made to help address pertinent issues recognized under this study.

2. OBJECTIVE AND RESEARCH QUESTIONS

The purpose of this study is therefore to analyze the potential environmental impacts of the oil and gas exploration and production on the coastal ecosystem and biodiversity of Ghana so as to make recommendations to help confront the situation right from the onset to avoid future consequences.

Objective: the specific objective of this research is:
'to analyze the potential impacts of oil and gas exploration and production on the coastal zone of Ghana and to propose recommendations for managing the associated environmental and socio-economic impacts'.

In order to achieve the above-mentioned objective, the following research questions are formulated.

Research questions:

1. What are the potential impacts of oil and gas exploration and production on the coastal ecosystem and people living in the coastal zone of Ghana?

This thesis commences with examination and analysis of potential environmental and social impacts likely to emanate as a results of the oil and gas exploration. According to the E&P Forum/UNEP Technical Report (1997) the potential impacts may depend upon many other things among which include: the stage of the process, the size and complexity of the project, the nature and sensitivity of the surrounding environment, the effectiveness of the planning, and mitigation techniques. Such impacts may include atmospheric, aquatic, terrestrial, human, socio-economic and cultural impacts. On the basis of time occurrence and the fate of substances, this thesis categorizes the various potential environmental impacts in orders of first (primary), second (secondary), and third (accumulated) impacts. Critical aspects in analyzing impact of offshore oil and gas exploration border on coastal ecosystem conservation, sustainability, services (utilization) and the geographical scale at which these impacts occur. The services of coastal ecosystem like any other ecosystem are themselves supplied at various spatial and temporal scales, which have a strong impact on the value different stakeholders attach to the services (Hein et al, 2006; Tacconi, 2000; Turner et al., 2000, 2003; Millennium Ecosystem Assessment, 2003). This thesis brings to bear the relationship between scales of Ghana's oil and gas impacts, coastal ecosystem services and socio-economic systems.

2. To what extent is Ghana's legislation able to cope with the environmental and socio-economic impacts of offshore oil and gas exploration?

Once the potential impacts of Ghana's oil and gas exploration are analyzed, the need to test the potency and ability of legislative measures to cope with these impacts become important. An

appropriate legislative framework gives both the host country and international oil company investors a clear legal and contractual context in which to negotiate a mutually advantageous exploration and production arrangements that develop the host country's petroleum resources (Onorato, 1995). A salient issue here is what constitutes the development of a country's petroleum resources. Since the publication of the Brundtland report in 1987, the world is alerted on the fact that equity, economic growth and environmental maintenance are simultaneously possible and that each country is capable of achieving its full economic potential whilst at the same time enhancing its resource base (WCED, 1987). In this case, the old perception of development by a mere transformation into a giant petroleum industry is gradually replaced by a view of reconciling economic and environment. However, despite the adoption of Brundtland approach to sustainable development in most developed countries, the concept is not fully established and/or implemented in the policies of most developing countries of which Ghana is included. This thesis examines the current legislation and policy frameworks of Ghana including institutional establishment that aim to minimize the negative impacts of oil and gas exploration.

3. What recommendations can help manage the associated environmental and socio-economic impacts of Ghana's oil and gas exploration?

It is not enough to identify the likely hazards of Ghana's oil and gas exploration and production without recommending measures to deal with or at least minimize these dangers. Recommendations even become more essential in view of the fact that Ghana is not well experienced in such an industry; institutions and legislations are not fully established or formulated to cope with the environmental hazards associated with such an industry. This thesis gives explicit recommendations based on the findings as well as lessons from similar studies elsewhere.

3. METHODOLOGY

3.1 General approach and scope

This study is based on ecosystem services approach. The Millennium Ecosystem Assessment (2003) defines the ecosystem services as the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth. The Convention on Biodiversity (CBD) defines ecosystem approach as a strategy for the integrated management of land, water and living resources that promote conservation and sustainable use in an equitable way. The approach recognizes that humans, with their cultural diversity, are an integral component of many ecosystems (UNEP/CBD 2000). Based on the above two definitions, I define the ecosystem services approach as a strategy for utilizing the benefits received from ecosystems to promote sustainable management of the ecosystems' resources in an integrated manner; this may necessarily include an integration of the ecosystem services into decision making. Conceptually, the ecosystem services approach is not different from the ecosystem approach as described by the Convention on Biodiversity. It is just a matter of terminologies. However, there seems to be a major difference on the scale and scope of definitions. For instance, the concept of ecosystem approach as described by the CBD goes a step further to embody equitable sharing of ecosystem benefits throughout society. Actually, it is almost impossible to use the ecosystem approach without referring to the benefits (services) derived from the ecosystems. In this regard, the ecosystem services form a foundation for the ecosystem approach. In this thesis, I identify the various benefits obtained from the coastal ecosystems, and then specifically use the concept of ecosystem services to analyze societal dependence and impacts of changes in these ecosystems.

Prominent concepts of the ecosystem services approach are conservation and sustainability. These concepts touch on the environmental problems and social issues confronting the oil and gas exploration and production industries at both the local and global levels. Amongst these challenges include: biodiversity and habitat protection, air pollution, marine and freshwater discharges, oil spillage, soil and groundwater contamination, socio-economic and cultural impacts etc. So on this basis, it can be said that the ecosystem services approach provides a valuable framework for analyzing and acting on the linkages between society and the environment. This in a way conforms to the concept of sustainable development as proposed in the Bruntland report (WCED, 1987), which presents a new trend in today's local and global industrial developments.

In this study, biodiversity is considered an integral part of ecosystem. The convention on biodiversity defines biodiversity as ''the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of

ecosystems''. Also, the ecosystem is defined as ''a dynamic complex of plant, animal and micro-organism communities and their nonliving environment interacting as a functional unit'' (UN, 1992: CBD Article2). So whilst diversity is a structural feature of ecosystems, variability among ecosystems is an element of biodiversity.

3.2 The study area

The main area for the crude oil and gas exploration and production is off the coast of the western region of Ghana and borders with the coast of La Cote D'ivoire. The western region of Ghana covers an area of about 2,391 square kilometers representing approximately 10% of Ghana's total land area and lies in the equatorial climate zone that is characterized by moderate temperatures with an average annual rainfall of about 1,600mm (ModernGhana, 2009). The Jubilee field, which had its name assigned by the government of Ghana in commemoration of Ghana's golden jubilee celebration in 2007, is the main field of operations. It is located within the Jubilee Unit Area and approximately about 60 km from the nearest coast of Ghana. Under the United Nations Convention on the laws of the sea (UNCLOS) of which Ghana is a signatory, Ghana claims rights within 12 nautical miles (nm) of territorial waters and a 200nm Exclusive Economic Zone (EEZ). So the Jubilee field is actually outside Ghana's territorial water but inside the 200nm Exclusive Economic Zone. The Jubilee Unit Area covers part of the Deepwater Tano and West Cape Three Points licence areas. It lies on the continental shelf offshore Ghana in water depths of between 1,100 and 1,700m and covers an area of approximately 110 km^2. The continental shelf has a generally regular bathymetry with isobaths running parallel to the coast. It has its narrowest (20 km wide) off Cape St Paul in the east and at its widest (90 km) between Takoradi and Cape Coast in the west. The shelf drops off sharply at about the 75 m depth contour. On the continental shelf, seabed sediments range from coarse sand on the inner shelf to fine sand and dark grey mud on the outer shelf. Sediments on the shelf and upper continental slope are predominantly derived from erosion of rocks from land, with smaller amounts of iron silicate sediments, and biogenic carbonate from mollusc shells. The seabed in the Jubilee field comprises soft to firm clays and silts that form a generally smooth seabed that slopes to the south-west. The Jubilee Unit Area is crossed by three submarine channels, which appear to be localized drainage points off the continental shelf. All three channels exhibit an active central gulley that meanders within each channel. The figure I below demonstrates the locations of Jubilee field and Jubilee Unit Area.

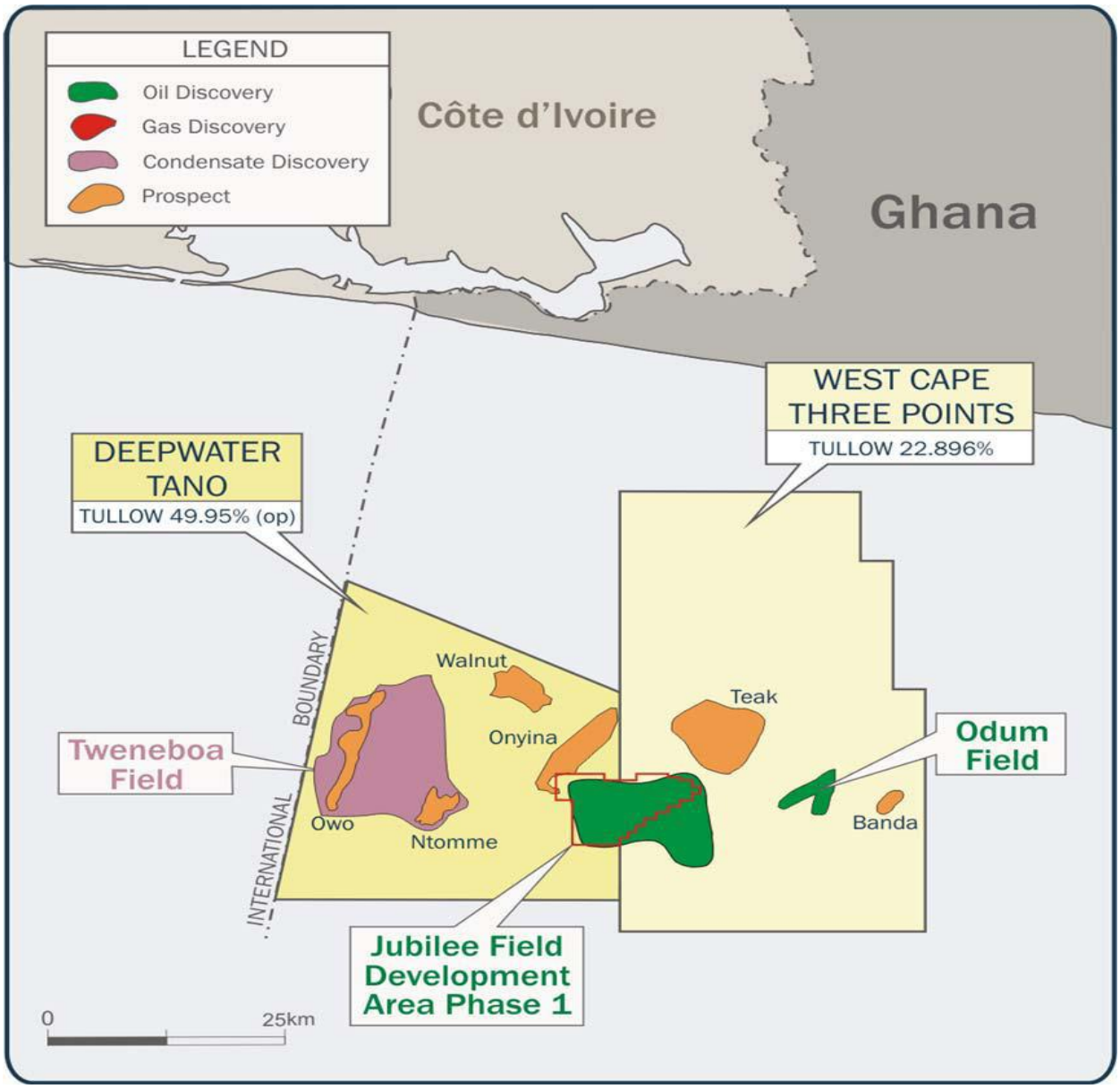

Figure 1: Ghana's offshore oil and gas exploration fields. (Credit: Tullow Oil)

3.3 Methods

Basically, this study is based on a literature review with secondary data from the field of environmental, ecological and social sciences. Interviews were conducted among experts and the stakeholders of the project for their knowledge and opinion. The methodology is specific for each research question and the details are as follows:

1. How can the potential impacts of oil and gas exploration on the coastal ecosystem and people living in the coastal zone of Ghana be analyzed?

The International Petroleum Industry Environmental Conservation Association (IPIECA) has a guideline on an Ecosystem Approach (EA) to oil and gas industry biodiversity conservation. Also, the United Nations Environmental Program (UNEP) proposes a guideline on biodiversity that is inclusive Environmental Impact Assessment (UNEP, 2005). In this study, the Pressure, State, Impact, Response, (PSIR) framework is used to establish the cause-effect relation between the exploration and production activities and the coastal ecosystem. Three orders of impact are distinguished as far as oil and gas exploration activities are concerned. First order concerns the impact of drill cutting, obnoxious substances and hydrocarbons on the coastal ecosystem as well as the inhabiting people; the second order involves the indirect effects associated with the first order or the entire exploration and production activities. This order may hinder ecosystem functions and/or affect the socio-economic setup of the society. The third order concerns loss of ecosystem services to the inhabiting coastal dwellers. These impacts are identified and analyzed based on the IPIECA, UNEP and the International Finance Corporation (IFC) guidelines.

The current ecosystem services and their values play a vital role in assessing the real cost of oil and gas exploration. Assessment of the coastal ecosystem services is based on the three-type services approach (production, regulation and cultural services) as proposed by Hein et al (2006). This approach is in agreement with the IPIECA guideline and also, it is based upon Pearce and Mille Turner (1990), Costanza et al. (1997), De Groot et al. (2002) and Millennium Ecosystem Assessment (2003). The reason for this framework lies on its strength to avoid or minimize double counting. For example, the supporting services as proposed by the Millennium Ecosystem Assessment (2003), is not included because they are reflected in other categories of services.

2. How can Ghana's legislation ability to cope with the environmental and social impacts of oil and gas exploration be analyzed?

The legislation and policy analysis are based on literature review. This includes a review of institutional provisions regarding coastal environmental governance. Here, I examine the various international environmental conventions of which Ghana is a signatory and then asses if Ghana's emission standards meet the international ones. Specifically, I analyze three main aspects of Ghana's legislation: (1) Adequacy of emission standards in Ghana (2) Applicability of these emission standards to the oil and gas industry and (3) Enforcement of legislation. I use the European Energy Agency (EEA, 2001) policy framework for reporting on the environment to evaluate the policies on safeguarding the coastal ecosystem and biodiversity of Ghana. The EEA framework entails analyzing the effects, relevance, effectiveness and cost-effectiveness of each policy. However, for the purpose of this study, I consider the effects, relevance and effectiveness aspects of the framework. As to whether a policy measure is cost effective is beyond the scope of this thesis. The EEA policy framework comprises three main compartments: policy process, outside world and evaluation. The policy process commences with the objective taking into

consideration the needs of the society. The objective(s) must be transformed into a kind of policy measures (outputs) but would require inputs in the form of human and financial resources. These policy measures would eventually have effects on the environment, the target group, the economy, and society. In effect the societal needs and the outcomes of the policy measures are in fact outside the policy processes. A schematic presentation of the European Energy Agency policy framework is demonstrated in figure 2 below.

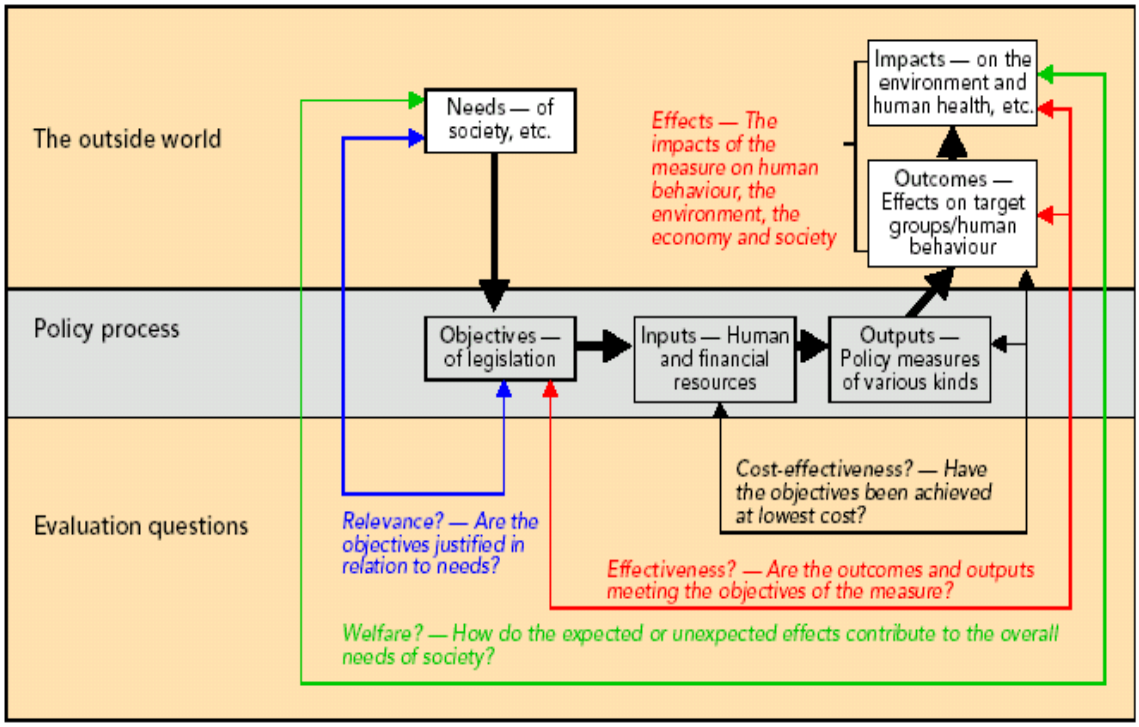

Figure 2: European Energy Agency Policy Framework; EEA (2001, p.20)

3. How can recommendations for managing the associated environmental and social impacts of Ghana's oil and gas exploration be made?

Explicit recommendations are given based on the findings of this study. Moreover, lessons from other well-established oil producing countries are used to improve upon the recommendations.

4. RESULTS

4.1 Impacts of oil and gas exploration and production on the coastal zone of Ghana

4.1.1 Oil and gas exploration and production description

Generally, two main parts are distinguished in the oil and gas industry: (1) upstream, which concerns with the exploration and production part of the industry and (2) downstream, which caters for the refining and processing of crude oil and gas products, distribution and marketing. Usually, a company in this industry may be fully integrated meaning it undertakes both the upstream and downstream operations or may just concentrate in just one aspect such as exploration and production alone or distribution or marketing. Within each part of the industry, there may be mini companies (commonly termed as the contractor companies) providing various degrees of services. For instance, the upstream may consist of sub-companies providing technical services like geophysical surveying, drilling and cementing or non technical services such as catering, hotels and cleaning services.

The oil and gas exploration and production basically involve five main processes: (1) prospecting surveying (2) exploration drilling (3) Appraisal (4) development and production (5) decommissioning and rehabilitation. The prospecting surveying starts with a review of geological maps to identify major sedimentary rock basins. This may be followed by an aerial photography to identify promising geological formations such as faults or anticlines. A field assessment is then done to gather more detailed information. Finally, surveying is undertaken using one of these three methods: magnetic, gravimetric and seismic. The exploration drilling involves creation of exploration wells ('wildcats') to confirm the presence of hydrocarbons and the thickness and internal pressure of reservoirs. In Ghana, self-contained mobile offshore drilling units (MODUs) are being used. The appraisal stage comprises determining the size of the oil field and hence the economic viability for development and production. Usually, more wells ('outstep' or 'appraisal' wells) are drilled to evaluate the size of the field, determine the nature of the reservoir, the number of confirming wells and also whether a further seismic work is required. If it is established that the oil field is economically viable, a reservoir is made out of many appraisal wells or from development wells. Here many developments take place such as the replacement of heavy drill pipe with lighter weight tubing in the well and also a control valve assembly replaces blowout preventer. Also at this stage of development, the underground pressures are maintained either by injecting gas, water or stream into the reservoir. Hydraulic fracturing of the hydrocarbon bearing formation and acid treatment may be done to increase the flow channels. Once the hydrocarbon reaches the surface, it is pumped into the production facility, which separates oil, gas and water. So, the development and production stage seeks to produce oil and gas from the reservoir through the geological formation pressure, artificial lift, and other advanced techniques until the oil reserve is fully depleted. The decommissioning and rehabilitation stage involves dismantling production structures and restoring the site to

environmentally acceptable standards. This is usually done at the end of the field's production life. However, in the course of production, wells that are found to be unproductive are decommissioned as well.

Hydrocarbon exploration in Ghana dates back to 1896 when oil seeps were found in the offshore Tano basin in the western region of Ghana. This eventually led to drilling of exploration wells in the vicinity of Half-Asini (GNPC, 2009). Till date, a total of about 10 discoveries have been made and about 79 exploration wells drilled in Ghana including 18 onshore wells. None but the Saltpond field, discovered in 1970 and located approximately 100km west of Accra, had undergone production between 1978 and 1985, producing about 3.47 million barrels of oil (MMbo) and flaring of 14 billion cubic feet of gas (Bcf) (GNPC, 2009). Hydrocarbon exploration and production activities remained dormant after 1986 till the year 2000 when operations were revived. Currently, exploration and production operations of various degrees are ongoing in Ghana's four sedimentary basins namely the Cote d'Ivoire-Tano Basin (including Cape Three Points Sub-basin), Central (Saltpond) Basin, Accra/Keta Basin and Inland Voltaian Basin.

The most promising discovery so far is the Jubilee field which was discovered in 2007. The Jubilee Unit Area covers part of the Deepwater Tano and West Cape Three Points licence areas. Initially, Kosmos Ghana HC, an exploring company, drilled the mahogany-1 well in the West Cape Three Points Block. This was later followed by another well, Hyedua-1, drilled by Tullow oil in the Deepwater Tano Block. It was later confirmed that there was a continuous hydrocarbon accumulation between the two concession areas. Subsequent appraisal wells namely mahogany-2, Hyedua-2 and mahogany-3 were completed by early 2009. The development of the Jubilee field is being undertaken under phases approach. The phase 1 includes an installation of a Floating Production Storage and Offloading (FPSO) vessel. In total, the phase 1 development consists of 17 wells; nine production wells used to bring oil and gas from the underground reservoir to the surface, six water and two gas injection wells to re-inject water and gas back into the reservoir for pressure maintenance and enhancing oil recovery. It is planned that five of the production wells and the three water injection wells target the Lower Mahogany reservoir whilst the remaining four production wells, three water injection wells and the two gas injection wells target the Upper Mahogany reservoir. A number of installed subsea wellheads, manifolds and pipelines will connect the wells to FPSO vessel which is designed to process and store the crude oil and gas. The processed crude oil will then be exported to the market and refinery through export tankers. Meanwhile, it is planned that the gas from the phase I development will be used to generate electric energy for the FPSO and also for re-injection into the wells. However, there are future plans to process the gas on-shore for power generation.

According to Ghana's deputy minister of energy, Dr. Kwabena Donkor, the phase 1 of the Jubilee field is expected to commence commercial operations in 2010 with a daily production capacity of about 120,000 barrels of oil and 120,000 million standard cubic feet of dry gas. The figures are expected to double, that is 240,000 barrels of oil and 240,000 million cubic feet of dry

gas, in the second phase of the Jubilee field project that is envisaged to commence in 2013. So far, the appraisals conducted indicate reserves of about 800 million barrels of crude light, with an upside potential of about three billion barrel (Ghanaweb, 2009a). It is estimated that the projected life span of 25 years of oil and gas production from the Jubilee field could earn the country as much as US$ 25 billion (Ghanaweb, 2009b).

Ghana's oil and gas exploration and production comes with many environmental and socio-economic challenges. These challenges may arise from one or more of the following: project footprint, operational discharges, air emissions, waste management, risk of oil spills, socio-economic and human impacts, cumulative and transboundary impacts.

4.1.2 First order of impact

The first order of impact in oil and gas industry comprises the activities with immediate effects or consequences on the surrounding environment. In Ghana's oil and gas exploration and production, each phase presents its peculiar primary impacts and these impacts are driven by the release of emissions, discharges, collisions and physical destruction of the seabed. These impacts with time, give rise to the second and third orders of impact. The table below illustrates the phases of production and their associated pollutants.

Table 1: Project phases and associated pollutants

Phase	**Activities**	**Type of impact**	**Sources**	**Pressures**
Prospecting	Aerial surveying	*Atmospheric* • Noise • Emissions	Low-level flights	Sound NOx and SO_2
	Seismic operations	*Aquatic* • Noise	Seismic equipment	Sound
		Human • Interference	Vessels interfering with other resource users e.g. fishing	

Phase	Activities	Type of impact	Sources	Pressures
Prospecting	Vessel operations	*Aquatic* • Discharges	Bilges, ballast water, sewage, spillage, garbage	Heavy metals e.g. Ba, Cd, Zn, Pb Garbage
		• Noise	Vessel engines	Sound
		Atmospheric • Emissions	Vessels combustion engines	CO_2, CO, NOx, VOC, SO_2, particulate matters
Exploration	Drilling and Appraisal	*Aquatic* • Noise	Mobile Offshore Drilling Unit (MODU)	Sound
		• Discharges	Drill cuttings, drill fluids Process, wash & drainage water Spills and leakages Sewerage, sanitary and domestic waste	Heavy metals e.g. Ba, Cd, Zn, Pb Oil, salt, benzene, PAH, Naturally occurring radioactive material (NORM) Sewerage and domestic waste

Phase	Activities	Type of impact	Sources	Pressures
Exploration	Drilling and Appraisal	*Atmospheric* • Emissions	Flaring, venting, purging gases Combustion from engines and gas turbines Particulate matters from disturbed sea beds and burning sources e.g. well testing	CO_2, CO, CH_4, NOx, VOC, SO_2, Hydrogen dioxide, particulate matters
		Human • Interference	Interference with other resource users e.g. fishing	
Exploitation (Development and production)	FPSO installation	*Aquatic* • Noise	FPSO equipment, supporting vessels propellers and helicopter movement	Sound
		Human • Interference	FPSO Interference with fishing boats and canoes	

Phase	Activities	Type of impact	Sources	Pressures
Exploitation (Development and production)	Processing and storage	*Aquatic* • Discharges	Produced water, gray water, black water, deck water, bilge water, ballast water, cooling water, oil spill, leaks, hydraulic fluids Solid waste	Heavy metals e.g. Ba, Cd, Zn, Pb; Oil, salt, benzene, PAH, NORM Garbage
		Atmospheric • Emissions	Flaring, venting, purging gases, vessels combustion engines, power generation plant, helicopter operations	CO_2, CO, CH_4, NOx, VOC, SO_2, Hydrogen dioxide, particulate matters, H_2S
	Transportation	*Aquatic* • Noise • Discharges	Tanker vessels Leaks, spillage, ballast water, grey water, bilge water	Sound Heavy metals e.g. Ba, Cd, Zn, Pb; Oil, salt, benzene, PAH, NORM

Phase	Activities	Type of impact	Sources	Pressures
Exploitation (Development and production)	Transportation	*Human* • Interference	Vessels interference with fishing boats and canoes	
		Atmospheric • Emissions	vessels combustion engines	CO_2, CO, CH_4, NOx, VOC, SO_2, Hydrogen dioxide, particulate matters

4.1.3 Second order of impact

The second order of impacts in oil and gas industry collectively includes those indirect effects that result from the project. For instance, the oil and gas exploration and production in Ghana comes with enormous job opportunities. This coupled with differences in salary levels are enough to serve as incentive for the inhabitants of the surrounding communities to abandon farming, fishing and other related economic activities for oil related jobs. Such a shift may result in other sectors of the economy particularly, the agricultural sector suffering. Also, the anxiety for better jobs around the oil and gas production area may result in population explosive in the coastal communities which would eventually put pressure on the existing public facilities such as hospitals, schools, public transport etc. Within the coastal ecosystem the impact of drill fluids, for example, on the coastal phytoplankton may have indirect consequences on its predators. Here, although the predator is by itself not directly affected by the drill fluids, the effect on its pray can have a serious consequences on the predator's survival. Likewise, the changes in water quality as a result of chemical discharges may also affect the ecosystem functions particularly of marine fauna. The secondary impacts may be ecological, anthropological health related or socio-economic in nature. A summary of potential secondary impacts of Ghana's oil and gas exploration and production include the following:

1. Increase in local population levels (immigration) leading to:

(a) Road congestion and traffic accidents

(b) Prevalence of diseases e.g. HIV Aids

(c) Social tensions such as:

- Pressure on social amenities: schools, health, and recreational facilities
- Degradation in aesthetic due to increase in slums
- Increased access to conserved or undeveloped areas

2. Impact on other sectors of the economy e.g. abandonment of farming for the oil and gas industry may affect agriculture.

3. High prices of goods and services, inflation, income differentiation.

4. Impacts on ecosystem functions

5. Introduction of non-native species

4.1.4 Third order of impact

These impacts are also referred to as accumulated impacts and they become manifested over a prolonged period of time. These may result from a continuous accumulation of the first and/or the second impact. Mostly, the ecosystem services within the environment where the exploration and production activities take place are hindered. The ecosystem services may be defined as befits people derive from ecosystems (Millennium Ecosystem Assessment, 2003). Hein et al (2006) distinguished three main types of services in natural and semi natural ecosystems. These include: production, regulation and cultural services.

(i) *Provisioning services* refer to the products or goods obtained from the ecosystem. Inhabitants of ecosystems usually utilize and convert energy into various forms, which are then utilized by humans. Examples include food, fuel, genetic resources, fiber, ornamentals, fodder, raw materials etc.

(ii) *Regulating services* reflect those benefits by virtue of the ecosystem's capacity to regulate essential ecological processes and life supporting systems through biochemical cycles and other biospheric processes. Such ecosystem services include carbon sequestration; climate regulations; control of albedo, temperature, rainfall pattern; flood control; pollination; biological nitrogen fixation, nutrient recycling etc.

(iii) *Cultural services* concerns the benefits people derive from ecosystems through recreation, cognitive development, relaxation, and reflection. This includes the

satisfaction that people gain from recognizing that a particular ecosystem contains a certain biodiversity or the fact that important cultural monuments are preserved. Examples under this service include habitat; provision of cultural, historic and heritage; scientific and educational information; recreation; tourism etc.

Based on studies conducted for the Environmental Protection Agency (Armah et al, 2004) on the coastal zones of Ghana, the following ecosystem services can be identified:

(a) *Food*: Fish species comprise the dominating pelagic stocks and demersal species. The pelagic stocks in the coastal waters of Ghana include round sardinella *(Sardinella aurita)*, flat sardinella *(Sardinella maderensis)*, chub mackerel *(Scomber japonicus)* anchovy *(Engraulis encrasicolus)*, horse mackerel (*Trachurus* sp.), little tunny (*Euthynnus alletteratus*), bonga shad (*Ethmalosa fimbriata*), African moonfish (*Selene dorsalis*), West African Ilisha (*Ilisha africana*), largehead hairtail (*Triciurus lepturus*), crevalle jack (*Caranx hippos*), Atlantic bumper (*Chloroscombrus chrysurus*), Barracuda (*Sphyraena* sp.), tuna and billfish. A total of 89 species are likely to be found in Ghanaian waters within the depth range in the Jubilee field (1,100 and 1,700m) (EPA, 2009).

The round sardinella schools in the coastal waters from the inshore to the edge of the continental shelf. It feeds mainly on the zooplankton, especially copepods except the juveniles which prefer the phytoplankton. The spawning seasons of the round sardinella coincides with the periods of coastal upwelling. Spawning take place in March, but the most significant spawning period is between July and October with peak spawning in August (Marine Fisheries Research Division, 2003). Juveniles tend to stay in nursery areas, but on maturity rejoin adult stocks offshore.The flat sardinella feed on a variety of small planktonic invertebrates, fish larvae and phytoplankton. They spawn in July. The small pelagic fish are preyed upon by the large ones such as Yellowfin tuna (*Thunnus albacares*), Bigeye tuna (*Thunnus obsesus*) and Skipjack tuna (*Katsuwonus pelamis*). The billfish are mostly not in large quantities in the coastal zone of Ghana and they comprise swordfish, Atlantic blue marlin, and Atlantic sailfish.

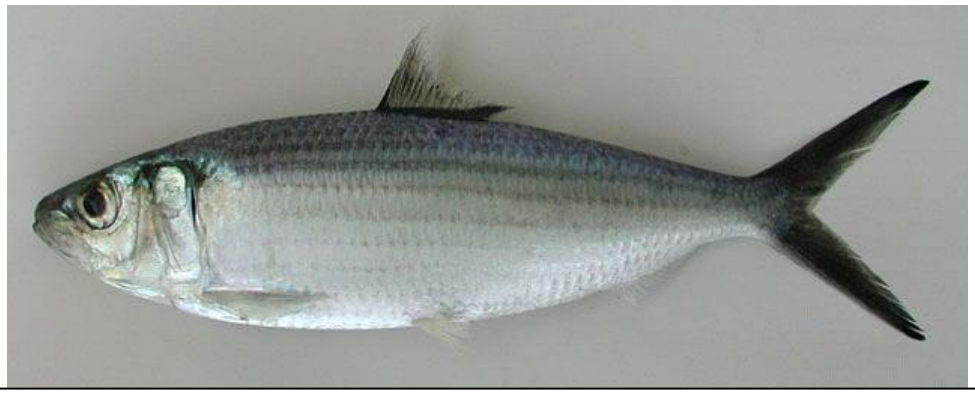

Figure 3: Flat sardinella *(Sardinella maderensis*) Source: Armah et al, 2004

Demersal (bottom living) species of commercial importance include redfishes, burros, croakers, snappers, goatfish, groupers and threadfins (Marine Fisheries Research Division, 2003).

Other coastal species that provide food include the shellfish, shrimps and prawns. The shellfish stocks in the coastal waters of Ghana are mainly scallops (*Chlamys purpuratus* and *Pecten Jacobeus*). However, the distribution of these bivalves is quite patchy and they are mostly sensitive to disturbances from trawlers Armah et al, 2004). Shrimp species in coastal waters of Ghana include penaeid species (*Penaeus notialis* and *Penaeus setiferus*). These species migrate from inshore waters to offshore areas to spawn. The migration is triggered by a decrease of salinity resulting from the freshwater run-offs during peak rainy periods in June and September. These fish species are particularly identified around the Cape Three Points where the Jubilee field is located (Armah et al, 2004)

(b) *Genetic resources*: The coastal waters of Ghana inhabit a number of diversified organisms that are of genetic and medicinal importance. Among these include the phytoplankton, zooplanktons, pelagic fish, offshore benthic invertebrate fauna communities, marine mammals, sea turtles etc. Common invertebrate fauna found in coastal waters of Ghana include polychaete worms, ribbon worms, amphipods, bivalves, gastropods, and decapod crustaceans. The abundance and distribution of these species are influenced by the seasonal climatic changes. Polychaetes and crustacean species have been recorded to increase in abundance with water depths whilst echinoderms, oligochaetes and sipunculid decrease in abundance with water depths.

(c) *Nutrient recycling*: The seasonal upwelling that take place in the Gulf of Guinea each year from June to late September (major upwelling) and in December-January (minor upwelling) bring cold, nutrient rich water to the surface causing blooms of plankton. During the upwelling periods the phytoplankton is dominated by diatoms such as *Leptocylindrus sp*, *Nitzchia sp*., *Chaetoceros sp.* and *Rhizosolenia sp* and *Skeletonema costatum*. During the periods of no upwelling, dinoflagellates are dominant. Proliferation of such phytoplankton is important for nutrient conversions in the coastal food chain. Also important is the numerous inhabiting coastal microflora and microfauna.

(d) *Habitat:* The coastal waters of Ghana serve as habitat for numerous species. Among these species include birds, turtles, marine mammals, molluscs etc. Marine turtles in particular are in the list of animals currently under protection by law in Ghana. Five species of marine turtles are found in the coastal waters of Ghana: the Hawksbill (*Erectmochelys imbricate*), the Leatherback (*Dermochelys coriacea*), the Loggerhead (*Caretta caretta*), the Green turtle (*Chelonia mydas*), and the Olive Ridley turtle (*Lepidochelys olivacea*) (Armah et al, 1997). The green and loggerhead turtles are listed by the (International Union for the Conservation of Nature (IUCN) as endangered, and the leatherback turtle is listed as critically endangered. According to Carr and Campbell (1995), the Olive Ridley turtle is the most abundant species in Ghana.

4.1.5 The on-shore ecology at the Cape Three Point

The onshore ecosystem around the Cape Three Point where the Jubilee field is located is of two types: Sandy shores and rocky shores. The sandy shores are known to serve as nesting places for sea turtles and as habits for species such as Ghost crab (*Ocypoda cursa*), the isopod *Excirolana latipes*, the amphipods *Urothoe grimaldi* and *Pontharpinia intermedia*, the mysid *Gastrosaccus spinifer*, mole crab (*Hippa cubensi)*, the polychates *Narine cirratulus*, *Glycera convoluta* and *Lumbrinereis impatien*s, the bivalve *Donax pulchellus* and the gastropods *Terebra micans* and *Olivancillaria hiatula*. Additionally, other bethic fauna and pelagic species can be found in shallow waters off the sandy shores. Strand vegetation in the sandy shores includes creepers: *Canavalia rosea*, *Ipomea pes-caprae*; and grasses: *Cyperus maritimus*, *Diodia vaginalis*. Further inland the sandy shores is characterised by vegetation which include dwarf palm, coconut palms, *Phoenix reclinata* and the shrubs *Baphia nitida*, *Grewia spp*, *Sophora occidentalis*, *Thespesia populnea* and *Triumfetta rhombaidea*.

The rocky shores serve as important habitats for macro algae, barnacles and littorinid snails, which use the rocks as substrate. Ecologically, algae mats on rocky shores serve as important micro-habitats for epifauna (i.e. crustacean, macro-invertebrates) and fish. Dominating species of macroalgae include: *Sargassum vulgare*, *Dictyopteris delicatula*, *Ulva fasciata*, *Chaetomorpha sp.*and *Lithothamnia sp.* The common snails are the *Littorina punctata*. Other snails often encountered include *Nodilittorina meleagris*, *Nerita senegalensis* and the whelk *Thais haemastoma*. The dominating limpets are *Siphonaria pectinata*, *Fissurella nubecula* and *Patella safiana.* At some sites oysters (*Ostrea sp.*) are found among the barnacles. Additionally, a number of fish species dominate the rocky shores and these include rainbow wrasses (*Coris julis*), parrot wrasse (*Callyodon*), morays and scorpionfishes.

Figure 4: Algae on rocky shore of Ghana. Source: Armah et al, 2004

Along the coast of Cape Three Point, rain forest fringes the Ehunli and Akpuhu Lagoons and an estuary where the rivers Nyile and Kpani meet along the western coastline. The Cape Three Point Forest Reserve occurs in this area as well. A total of 141 species belonging to 58 diverse

plant families made up of trees, shrubs, herbs, grasses and sedges have been observed in this area (Armah et al, 2004).

4.2 Ghana's legislation ability to cope with the environmental and socio-economic impacts of oil and gas exploration

4.2.1 Overview of relevant national legislation and policies

Legal frameworks for coastal zone management in Ghana include:

The constitution

EPA Act, 1994 (Act 490

Environmental Assessment Regulations, 1999 (LI 1652)

Local Government Act, 1993 (Act 462)

Environmental Standards and Guidelines

4.2.1.1 The constitution

The constitution of Ghana requires that all citizens (employees and employers) protect and safeguard the natural environment of the Republic of Ghana and its territorial waters. This is specifically stated in Article 41(k) in Chapter 6 of the constitution. The sustainable use and conservation of marine resources are encouraged through legislation, regulations, education and awareness creation programs as well as the enforcement of existing legislation. Specific sectoral frameworks include:

(a) The legal framework for Fisheries Resources, which are:

- Fisheries Law 1971 (PNDCL 256)
- Fisheries Act 625 (2002)

The Fisheries Act 625 (2002) established the Fisheries Commission with a directorate whose mission is "…to promote sustainable exploitation and responsible utilization of fishery resources of Ghana through sound management practices, research, appropriate technological development for both culture and capture fisheries, effective extension and provision of other support services to fish farmers, fishermen, fish processors and traders for improved income and fish food security". The commission as a body regulates and manages the utilization of the fishery resources of Ghana and coordinate related policies. Also, the commission is tasked to ensure proper conservation of fishery resources through the prevention of over fishing. Administratively, the directorate has sub departments at regional levels which are responsible for carrying out and implementing policies of the fishery directorate at the various regions. Operational divisions within the directorate include inland fisheries management (and

aquaculture); marine fisheries research; monitoring; control and surveillance; and finance and administration.

The section 91 allows for the establishment of marine reserves and prohibits fishing, dredging and removal of sand or gravels and the disturbance of natural habitat without permission of the Minister. Section 92 prohibits the pollution of water that may have an adverse effect on aquatic resources and provides details of penalties. Section 93 requires that the Fisheries Commission be informed of any activities likely to have substantial impact on fishery resources before commencement of the activity and allows the Fisheries Commission to require reports and recommendations by the proponent on the likely impact of the activity and possible means of preventing or minimizing adverse impacts which shall be taken into account in the planning of the activities.

(b) The legal framework for Ecosystem Protection, which are:

- Maritime Zones (Delimitation) Law (PNDCL 159 of 1986)
- Wild Animals Preservation Act 1961 (Act 43)
- Wildlife Conservation Regulations 1971 (LI685)
- Wild Reserves Regulations 1971 (LI 740)
- The Wetland Management (Ramsar sites) Regulation, 1999
- Oil in Navigable Waters Act, 1964 (Act 235)

The Maritime Zones (Delimitation) Law (PNDCL 159 of 1986) defines the extent of the territorial sea and Exclusive Economic Zone (EEZ) of Ghana. The territorial sea is defined as those waters within 12 nautical miles (approximately 24 km) of the low waterline of the sea. The Act defines the EEZ as the area beyond and adjacent to the territorial sea less than two hundred nautical miles (approximately 396 km) from the low waterline of the sea. The Act also grants the rights, to the extent as permitted by international law, to the government of Ghana for the purposes of:

"exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to any other activities for the economic exploration and exploitation of the zone, such as the production of energy from the water, currents and winds…"

The *Oil in Navigable Waters Act (Act 235 of 1964)* is concerned with the control of water pollution. The Act makes the discharge of any oil or mixture containing oil from any vessel or from land an offence. The owner or master of the ship, or the occupier of the land, or person in charge of the apparatus from where the oil was discharged, may be charged and found guilty of the offense.

Section 1 of the Act regulates the discharge of oil into prohibited areas of the sea. The Act extends the prohibition of pollution to the high seas by ships registered in Ghana and requires

that Ghanaian ships be fitted so as to prevent oil fuel leakages or draining of oil into the bilges (unless the oil in the bilges is not discharged).

(c) The legal framework for Oil and Gas Industry

- Ghana National Petroleum Corporation Act (Act 64 of 1983)
- Petroleum (Exploration and production) Law 1984 (PNDCL 84)
- National Petroleum Authority Act (Act 691 of 2005*)*
- Mineral (Offshore) Regulations 1963 (LI 257)
- Mineral (Oil and Gas) Regulations 1963 (LI 256)
- Oil and Mining Regulations, 1957 (LI 221)

The *Ghana National Petroleum Corporation Act (Act 64 of 1983)* established the Ghana National Petroleum Corporation (GNPC) with mandate to:

• promote exploration and planned development of the petroleum resources of the Republic of Ghana;

• ensure the greatest possible benefits from the development of its petroleum resources;

• obtain effective technology transfer relating to petroleum operations;

• ensure the training of citizens and the development of national capabilities; and

• prevent adverse effects on the environment, resources and people of Ghana as a result of petroleum operations.

The *Petroleum (Exploration and Production) Law (Act 84 of 1984)* establishes the legal and fiscal framework for petroleum exploration and production activities in Ghana. The Act sets out the rights, duties and responsibilities of contractors; details for petroleum contracts; and compensation payable to those affected by activities in the petroleum sector. *Act 84* gives regulatory authority to the Ministry of Energy on behalf of the State. All petroleum operations are required to be conducted in such a manner as to prevent adverse effects on the environment, resources and people of Ghana. The act requires that a Plan of Development (PoD) for proposed developments be submitted and approved by the GNPC, The Ministry of Energy and the EPA before development of the field. In addition, an Environmental, Health, and Safety (EHS) Manual, containing details on health, safety, and environmental issues, policies and procedures must be submitted to the GNPC for review before commencement of development activities. The Act further requires that the EPA and the GNPC conduct EHS audits of operations. The Act requires that emergency plans for handling accidents and incidents are discussed and agreed upon with the GNPC and the EPA before the commencement of operations.

The *National Petroleum Authority Act (Act 691 of 2005)* established the National Petroleum Authority (NPA) of Ghana with a mandate to regulate, oversee and monitor downstream

petroleum activities. The NPA is also mandated to establish a Unified Petroleum Price Fund and provide for the regulation and licensing of storage and selling of petroleum products.

d) The legal framework for Tourism Promotion (including coastal tourism)

- Ghana investment Promotion Centre Act 1994 (Act 478)
- Companies Code 1963 (Act 179)
- Free Zone Act 1995 (Act 504)
- Ghana Tourism Board
- Ghana Commission on Culture

4.2.1.2 EPA Act, 1994 (Act 490)

The Environmental Protection Act (Act 490 of 1994) establishes the authority, responsibility, structure and funding of the Environmental Protection Agency (EPA). Part I of the Act mandates the EPA with the formulation of environmental policy, issuing of environmental permits and pollution abatement notices and prescribing standards and guidelines. The Act defines the requirements and responsibilities of the Environmental Protection Inspectors and empowers the EPA to request that an Environmental Impact Assessment (EIA) process be undertaken.

Section 10 of Part 2 of the Act provides for the establishment of a hazardous chemicals committee, comprising representatives from key government organizations with an interest in chemical management, to monitor and advise the EPA on the importation, exportation, manufacture, distribution, use and disposal of hazardous chemicals. However, the Act does not define certain important terms which have been used such as chemicals, toxic substances, and substances which are hazardous. The EPA's division, Chemicals Control and Management Centre (CCMC), plays an important role in the management of chemicals in Ghana. The CCMC's primary objective is to protect human health and the environment from the possible effects of chemicals. The CCMC issues chemical clearance permits to importers of industrial chemicals. It is mandatory for applicants to submit an application form and copies of the Material Safety Data Sheets (MSDS) of every chemical they intend to import into Ghana to the CCMC. These applications are subsequently screened based on the information provided on the MSDS and other sources. The CCMC also supervises the disposal of obsolete chemicals.

Section 2(f) of the *Environmental Protection Act (Act 490 of 1994*) enables the EPA to issue pollution abatement notices for:

…"*controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment…"*

Section 2(h) of the Act allows the EPA to prescribe standards and guidelines relating to air, water, land and other forms of environmental pollution. Section 2(j) requires the EPA to co-operate with District Assemblies and other bodies to control pollution.

4.2.1.3 Environmental Assessment Regulations, 1999 (LI 1652)

Environmental Assessment Regulations, 1999 (LI 1652) is a principal enactment within the *Environmental Protection Act (Act 490 of 1994)* and it requires that an Environmental Impact Assessment (EIA) process be undertaken. Specifically, all activities likely to have an adverse effect on the environment must be subject to environmental assessment and issuance of a permit before commencement of the activity. The Regulations set out the requirements for the following:

• Preliminary Environmental Reports (PERs);

• Environmental Impact Assessment (EIA);

• Environmental Impact Statements (EISs);

• Environmental Management Plans (EMPs).

• Environmental Certificates; and

• Environmental Permitting.

4.2.2 Relevant international environmental agreements and conventions

Environmentally related conventions ratified by Ghana include:

(a) *United Nations Convention on the Laws of the Sea*: 10 December 1982

This international convention has been implemented in Ghana's national legislation in *The Maritime Zones (Delimitation) Law (PNDCL 159 of 1986)*. Under this convention Ghana claims rights within 12 nautical miles (nm) of territorial water and a 200 nm Exclusive Economic Zone (EEZ).

(b) *The MARPOL Convention*

The *International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)* makes it a mandatory that the ratified parties should accept the *Regulations for the Prevention of Pollution by Oil (Annex I)* and *Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (Annex II).* However, the later four additional annexes can be voluntarily accepted. In this case, Ghana has till date ratified only the first two mandatory annexes. The convention specifies general requirements regarding the control and discharges of waste oil, engine oil, grey and black waste water in the sea.

(c) *International Convention of Oil Preparedness, Response and Co-operation (OPRC), adopted 1990.*

This convention requires parties to undertake comprehensive measures to deal with threats or major incidence of marine pollution. The convention calls for the establishment of stockpiles of

oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents. Parties to the convention are required to provide assistance to others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided.

(d) *The Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention).*

Ghana gained accession to the Basel Convention on 30 May 2003 which makes it obligatory for Ghana to conform fully to the convention. Under this convention, producers of hazardous waste are required to dispose of their waste in an environmentally responsible manner close to where it is generated. However, provisions are made for certain countries to transport their waste especially where it is deemed that the state of export does not have the capability of managing or disposing of the waste in an environmentally sound manner. In this case, Ghana qualifies to export waste but must fully comply with the provisions of the Basel Convention.

(e) *Convention on the Ban of the Import into Africa and the Control of Transboundary Movement of Hazardous Wastes within Africa (Bamako Convention)*

This convention is more or less supplementary to the Basel convention and seeks to control the importation and movement of dangerous waste into and out of the African states which are parties to the convention.

(f) Other related conventions

Other conventions ratified by Ghana, which have the potential to overcome the impacts from the oil and gas exploration, include:

- *International Convention for the Prevention of Pollution of the sea by Oil (21 October 1962);*
- *International Convention on the Establishment of an International Fund for Compensation of Oil Pollution Damage: 18th December, 1971*
- *The International Convention for the Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981(Abidjan Convention)*
- *Africa Convention on the Conservation of Nature and Natural Resources (15 September 1968);*
- *International Convention on Civil Liability for Oil Pollution Damage (29 November 1969);*

- *Convention on Wetlands of International Importance, Especially as Waterfowl Habitats (2 February 1971);*
- *Convention Concerning the Protection of World Cultural and Natural Heritage (16 November 1972);*
- *Convention on the Conservation of Migratory Species of Wild Animals (23 June 1979);*
- *International Convention for the Conservation of Atlantic Tunas (4 May 1966);*
- *Convention for the Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981* (Abidjan Convention);
- *Montreal Protocol on Substances that Deplete the Ozone Layer (24 July 1989);*
- *Framework Convention on Climate Change (June 1992);*
- *Convention on Biological Diversity, 1992;*
- *International Covenant on Economic, Social and Cultural Rights (7 September 2000);*
- *International Covenant on Civil and Political Rights (7 September 2000);* and
- *African Charter on Human and Peoples' Rights (Acceded 24 January 1989).*
- *United Nations Conference on the Human Environment (1972)*

4.3 Analysis of the potential impacts on the coastal ecosystem and people living in the coastal zone of Ghana

The various orders of impact are not completely independent from each other; one influences the other. For instance, a physical disturbance of the seabed as a result of drilling and infrastructure installations would primarily or directly destroy the habitats of certain benthos species. However, the sediments released as a result of seabed disturbance are highly potential to give rise to secondary respiratory problems of other fish species or biodiversity. A persistent blockage of respiratory organs may eventually cause death and thereby affect the provisioning services of the ecosystem. This example portrays a chain starting from the first order to the third order of impact. The perpetuation of impacts in this way makes it essential that the potential impacts are considered and analyzed collectively. On that basis, I analyze the impacts according to the pressures or pollutants associated with the three orders of impact in two main headings: the ecosystem and socio-economic impacts.

4.3.1 Impact on ecosystem and biodiversity

4.3.1.1 Noise

As earlier revealed in table (1), the exploration through to the development and production stages are associated with pressures which include sound (noise) from seismic operations, vessels and helicopter activities. Noise at certain levels is intolerant by some marine organisms and can interrupt with their functions within the ecosystem. In extreme situations, noise can cause temporary or permanent auditory trauma to marine mammals and sea turtles within a range of a several hundred meters of a typical airgun array, particularly if they swim beneath the array. Richardson *et al*. (1995), reported that structures in human ears and those of most marine mammals are sensitive to changes in sound pressure and that sound in coastal waters can interfere with the ability of marine mammals to detect calls from individuals of the same species, echolocation pulses or other important natural sounds. Fish and marine mammals including cetaceans (whales and dolphins) are particularly affected most by sound elevations in coastal waters because of their dependence on sound for reproduction, feeding, avoiding hazards like predators, and navigation (Tyack and Miller 2002; Popper 2003; McCauley, 1994). The impacts of noise on cetaceans have been further uncovered by a study conducted by Parente et al. (2007). In their study, they recorded no significant change in all measured oceanographic conditions except for seismic survey noise, which was kept at elevated level. The study reported a decline in cetacean diversity in areas under intense seismic noise whilst those areas without intense seismic noise recorded a rise in cetacean diversity. This report suggests a decline in cetacean population with an increase seismic noise.

The effects of sound in coastal waters originate from two main sources: (a) natural such as wave noise, rainfall, lightning strikes on water, earth quakes etc and (b) anthropogenic or man made, which includes those from oil and gas industry and vessels. However, as Rabin and Greene (2002) noticed, the coastal animals might have evolutionary adapted to the natural coastal noises but the development of the anthropogenic sources are comparatively recent and their levels are rapidly rising such that coastal animals are unlikely to 'keep pace' and adapt genetically. Other effects of noise on marine animals have been reported to include death, reduced growth, reduced production, impaired hearing and stress (Fernández et al. 2005; Slotte et al. 2004; Wysocki et al. 2006).

Considering the rich biodiversity of Ghana's coastal waters which includes marine mammals and some endangered species of marine turtles, it is apparent that the offshore exploration and production noise would negatively affect these animals. Most of the machinery and vessels used in oil and gas exploration and production are capable of generating noise levels between 120 and 220 **(**dB re 1 µPa at 1m) and are generally of low frequencies with the maximum of about 100 kHz (Richardson *et al*, 1995). Meanwhile, the coastal water of Cape Three Point is considered a migratory route for most whales and dolphins especially in Dixcove beach area where these mammals have been spotted (Van Waerebeek et al, 2009). Some of the sighted cetaceans in and

around the operational area and the adjacent waters of the neighboring La Cote d'Ivoire include the most noise sensitive species such as the sperm whale and baleen whale (humpback whale). These species exhibit behavioral responses at noise levels between 120 dB and 180dB (McCauley, 1994). Important to note is the fact that these levels are below and /or within that produced by the oil and gas operational machinery and vessels. Nevertheless, the noise may either enhance diversion of the cetaceans' route or prompt avoidance of such areas. Stone (2003) reported that during seismic surveys in U.K. waters, several dolphin species were seen less frequently when airguns were firing than when they were not firing. In addition, baleen whales, killer whales, and all of the small odontocetes were farther from large airgun arrays during periods when airguns were firing than when the airguns were silent. In general, small odontocetes showed the strongest avoidance response to seismic activity, with baleen whales and killer whales showing some localised avoidance, pilot whales showing few effects, and sperm whales showing no observed effects from these data. Different groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys (Stone, 2003). If elevated noise triggers route diversion then it is apparent that not only Ghana will suffer the consequences but the sub-region as a whole. The implication is that Ghana and the sub-region (including Cote d'Ivoire) may lose on tourism which otherwise could have been a great source of revenue and employment.

Figure 5: Atlantic spotted dolphin, *Stenella frontalis,* offered for sale on Dixcove's landing beach on 3 Jan 2003. Source: (Van Waerebeek et al, 2009)

Figure 6: Adult-sized pygmy killer whale *Feresa attenuata,* landed at Dixcove beach on 31 Dec 2007 Source: (Van Waerebeek et al, 2009)

Figure 7: Two long-beaked common dolphin *Delphinus capensis,* landed alongside a smooth hammerhead shark and an unidentified billfish (Istiophoridae) at Dixcove, on 18 Oct 1999. Source: (Van Waerebeek et al, 2009)

Additionally, the shore of Cape Three Point ranges from sandy to rocky beaches. Specifically, the coastline between Domini Lagoon, Amunsure Lagoon and Essiama Beach in the west of Cape Three Point is mainly a sandy beach. This coastline therefore presents a suitable environment for marine turtles to nest during the breeding season. However, the noise associated with oil and gas exploration activities poses a threat to this function. Since noise intensity decreases with distance, it is reasonable that the effects are more pronounced within the immediate periphery of operations. At first, the 60km distance between offshore operations and onshore turtle nesting sites might be too wide a distance to consider noise a threat to the onshore ecology. However, the associated helicopter trips, export tankers and the frequent trips of supply vessels between Takoradi and the Jubilee Field are enough to create such a noise level to negatively impact on both the offshore and onshore ecosystem functions. Again these areas present an opportunity to develop Ghana's tourism industry especially for those interested in

observing hatched turtles and migratory marine mammals. But such an opportunity may not be realized under the current oil and gas exploration and production in the area.

Currently, Ghana has no regulations or guidelines for noise mitigation during seismic surveys and operations. The project's EIA indicates that the oil producing company (Tullow oil) 'will develop and enforce a specific policy and procedures to ensure that traffic and operations of drilling vessels, support vessels and helicopters will minimize disturbance to marine mammals. For example, vessels will not be allowed to intentionally approach marine mammals and, where practicable, will alter course or reduce speed to further limit the potential for disturbance or collision'. However, the specific policy and procedures are not explicit and beside that the EIA came late (about 2 years after discovery) so any impact associated with seismic surveys could have already occurred.

4.3.1.2 Physical destruction

Another ecological impact from the offshore oil and gas industry arises from the loss of habitat and biodiversity due to the construction and installation of subsea infrastructure. Such installations do not only directly destroy the habitats but also give rise to suspended particles which can either smother certain species or may lead to secondary impacts through blockage of respiratory organs of certain fish species. Eventually the destruction of habitats of certain species would potentially reduce prey availability and indirectly affect their predators. It is obvious that irrespective of how small the area of installations might be in relation to the total area of operations, the loss of biodiversity and habitat in any quantity still represents an impact on the marine ecology. In effect, such losses may compel species such as pelagic fish to travel farther distances away from the easy reach of local canoe operators.

4.3.1.3 Operational discharges and emissions

The Jubilee field exploration and production comes with many operational discharges including drill cuttings, drill fluids, air emissions, water and solid waste discharges. These result in the release of toxic and obnoxious materials into the coastal water. Although some of these discharges and emissions are injurious to the recipient ecosystem and biodiversity, their effects may not be immediately conspicuous as witnessed in huge oil spillage. Underwood and Peterson (1988) noted that when chronic long-term disturbances act through sub lethal effects on organisms, the population abundances of valued species and the ability to sustain provision of ecosystem goods and services into the future, becomes especially problematic.

4.3.1.3.1 Drill cuttings and drill fluids

The first discharges associated with the first order of impacts involve the release of drill cuttings and drill fluids at the exploration drilling stage. Basically, two types of drill fluids are used in Ghana's oil and gas exploration and production: (1) Water Based Fluids (WBFs) and (2) Non-aqueous drilling fluids (NADFs). In an individual well, the WBFs are used at the initial drilling stages (to a depth of about 700m or 1100m) and it is followed by the NADFs as the well gets

deeper. The usual practice with the WBFs is to discharge the drilling mud unto the seabed. Normally, drill fluids especially the NADFs are often reconditioned and reused in the wells until such a time that it cannot be continuously used. The NADFs are then treated and discharged onshore. However, in the process of drilling, these fluids eventually mix up with the drill cuttings which are discharge unto the sea bed. Under certain conditions, the discharges happen at the water surfaces, which mean more chemicals and sediments get suspended in the coastal water. Most of these drill fluids especially the NADFs contain aromatic compounds, which are very injurious to the recipient ecosystem and biodiversity. The advantage of using the NADFs lies in its ability to give fewer drilling problems and efficient drilling.

In spite of the fact that most oil industries do not associate toxicity with WDFs, Patin (1999) argues that the WDFs can still damage the marine life. Leaving aside the question of toxicity, water based mud (WBMs) deposited on seabed sediments may smother benthic animals and, if in the form of very fine particles suspended in the water, can interfere with respiration in small marine animals and pelagic fish. Small (pellet) fractions gradually spread over large distances. Particles less than 0.01mm in size can glide in the water column for weeks and months. As a result, large zones of increased turbidity are created around drilling platforms. These phenomena, on an even larger scale, happen during the laying of underwater pipelines, construction of artificial islands, bottom dredging, and some other activities that accompany offshore oil production operations. At the same time, the increased turbidity can pose a certain risk. The persistent plumes of increased turbidity disturb the balance of production-destruction processes in the surface (photic) layer of seawater. It can also cause disturbances at the ecosystem level. According to Shparkovski (1993), a short-term increase in concentration of pellet suspension (particles with a size of 0.005-0.01mm) above the level of 2-4 grams per litre caused quick adverse effects and death to fry of salmon, cod and littoral amphipod.

According to Patin (1999), ferro-chrome lignosulfonate, a common drilling mud additive used as a thinner and deflocculant, has reported effects on survival and physiological responses of fish eggs and fry; the filtration control additive CMC (carboxy-methyl-cellulose) can cause death in fish fry at high concentrations (1,000-2,000mg/l) and physiological changes at 12-50 mg/l, whereas at the low concentrations (1-20mg/l) used in standard chronic tests it has no observed effects. Other additives used as defoamers, descalers, thinners, viscosifiers, lubricants, stabilisers, surfactants and corrosion inhibitors all have reported effects on marine organisms, ranging from minor physiological changes to reduced fertility, lower feeding rates and higher mortality, depending on the concentrations.

The general view on drill muds, as revealed in the Paris convention, stand on the fact that they are not readily degradable or rendered harmless by natural processes; and they may either: (a) give rise to dangerous accumulation of harmful material in the food chain, (b) endanger the welfare of living organisms causing undesirable changes in the marine eco-systems, (c) interfere seriously with the harvesting of sea foods or with other legitimate uses of the sea; and (d) contain one or more of these pollutants which demand urgent action: organohalogen compounds and

substances which may form such compounds in the marine environment, mercury and mercury compounds, cadmium and cadmium compounds, persistent synthetic materials, persistent oils and hydrocarbons of petroleum origin. Apparently, not only would these constituents impact negatively on the marine ecology but also are highly potential to cause secondary impacts particularly to the health of Ghana's coastal dwellers.

4.3.1.3.2 Water discharges

The water discharges may come from: (a) routine sources: black water, grey water and food waste (from FPSO and MODUs); deck drainage and bilge water; produced water (b) non-routine Discharges: occasional discharge of ballast waters (from export tankers), hydraulic fluid from subsea valve activation, completion fluids and occasional discharge of workover fluids (from

MODUs), and chemically treated hydrotest waters from the subsea infrastructure during installation and commissioning. Like the drill muds, these discharges contain a significant amount of hydrocarbons, heavy metals and arsenic which can affect the marine ecosystem. For instance, Neff (1987) described the produced water for ocean discharge as containing up to 48 parts per million (ppm) of petroleum, because it had usually been in contact with crude oil in the reservoir rocks. There were also elevated concentrations of barium, beryllium, cadmium, chromium, copper, iron, lead, nickel, silver and zinc, and "small amounts of the natural radionucleides, radium226 and radium228 ("very little" of which became attached to nearby sediments) and "up to several hundred ppm of non-volatile dissolved organic material of unknown composition". He added that "in shallow, turbid waters, elevated concentrations of hydrocarbons may be detected in surficial sediments up to about 1,000m from the discharge"; and that the aromatic hydrocarbons and metals in produced water were toxic; "the toxicity of the soluble organic fraction of produced water is not known". It is apparent that the organic fraction of produced water can induce eutrophication and thereby affect the biological oxygen demand (BOD). Such a situation can gradually but eventually turn from a local problem to a regional, national and transboundary problems especially when the project field is close to the coastal boundary of La Cote d'Ivoire.

Additionally, an obvious pollution associated with maritime traffic is the release of ballast water into the coastal ecosystem. These waters usually contain animals and plants that accidentally hitchhike along with the vessel from one part of the world to another. The transported plant and animal species usually do not have natural enemies at their new locations hence they multiply rapidly and can become ecological pests. With the oil and gas production and exportation, maritime traffic on Ghana's coastal waters is bound to increase bringing in such problems. A typical example is the Eurasian zebra mussel (*Dreissena polymorpha*) in the North American Great Lakes, resulting in expenses of billions of dollars on research, control operations and the treating of fouled underwater structures and water pipes (Kloff and Wicks, 2004). Considering such huge expenses in the control of such pests, the ability of Ghana to deal with this threat is woefully inadequate. This implies more adverse effects on the functioning of coastal ecosystems.

The situation can also have indirect effects on other sectors of the economy since money spent on controlling these pests could better been spent to strengthen other sectors.

4.3.1.3.3 Air emissions

The emissions from the Jubilee Field project are likely to originate from MODU operations for well completions (power generation exhaust emissions); FPSO operations (power generation exhaust emissions and non-routine flaring); marine support vessels and helicopters (power generation exhaust emissions); filling, offloading and operation of export tankers (exhaust and fugitive emissions); and dust from increased traffic and dry handling of dry goods.

These emissions consist of carbon monoxide (CO), carbon dioxide (CO_2), sulfur oxides (SOx), methane (CH_4), non-methane volatile organic compounds (VOC) and nitrogen oxides (NOx). NOx emissions contribute to eutrophication, acidification, and the formation of ground-level ozone, and result in higher background concentrations of NO_2. Non-methane hydrocarbons emissions combined with NOx result in the ozone formation, while CO_2 and CH_4 can contribute to global warming. The SOx and NOx can undergo chemical reaction in the atmosphere to generate several secondary contaminants, such as sulfuric and nitric acids. These contaminants come down as acid rain into the soil and the ocean, thus affecting the fauna and flora of the region.

The effects of the acid rain would not only be felt in the marine ecosystem but also, the onshore ecology particularly the Ankasa conservation area which comprises the Nini-Suhien national park and the Ankasa resource reserve. The reserve occupies an area of about 500km^2 and it is within the pollution deposition distance of the Jubilee Field's oil and gas exploration. The reserve is considered the richest forest in terms of botanical diversity in the country. Among the biodiversity include about 300 plant species recorded per hectare, forest elephants, bongo, primates including endangered Diana monkeys, birds of about 263 species recorded. As such, it attracts researchers and tourist all year round thus considered a major foreign exchange earner. However, these ecosystem services are much threatened by the over 20-year pollution from the oil and gas exploration. The situation is worrying in view of the fact that Ghana and the Sub-Saharan Africa do not have a model such as the European Regional Atmospheric Information Simulation (RAINS). In this case, the effect of such pollution on the ecosystems of Cote d'ivoire is not determined but can be catastrophic. Such a situation has a tendency to create transboundary political tension.

Figure 8: Entrance to Ankasa Conservation Area, western region of Ghana. Source:www.ghanaexpeditions.com

4.3.1.3.4 Solid waste discharge

The Jubilee Field project is expected to generate both hazardous and non-hazardous solid waste. According to the Tullow Oil's estimate, about 100 tonnes and 200 tonnes respectively of hazardous and non-hazardous wastes are expected to be generated per annum. The hazardous waste comprises oily wastes, lubricants; supply vessel tank sludge clean out; chemicals; glue; paint, thinner, paint tins; batteries; rubber; fluorescent tubes; filters; and medical waste. The non-hazardous solid waste may consist of plastic packaging; kitchen waste; paper and cardboard; glass; wood; cabin domestic waste. These wastes are expected to be transported ashore for proper treatment and disposal. However, considering the cost involved in transporting and managing such wastes, the industries often prefer grounding the organic stuff and disposing onsite. Beside that, solid waste treatment facilities in the western region are woefully inadequate; for example municipal dumping places are still being used and are not properly controlled. Whilst these dumping areas are generally for non-industrial and non-hazardous solid waste, it is more likely that most of these solid wastes from the oil and gas exploration would end up there. Ideally, some wastes with low organic content, such as some drill cuttings, should be suitable for treatment by biological or other waste treatment options (e.g. on land). Other wastes with low levels of contamination may be suitable for hazardous waste landfill. However, currently there are no hazardous waste landfill facilities, no chemical waste treatment facilities and no thermal treatment facilities other than basic combustors for medical waste at some hospitals in Takoradi and in Ghana as a whole. If these industrial wastes end up at the municipal dumping places then they may get drained and contaminate surrounding ecosystems. The risks include acidification of crop lands, ground and surface water contamination, human exposure to harmful pollutants, flora and fauna contamination and a possible bioaccumulation of obnoxious pollutants in these flora and fauna.

4.3.1.4 Oil spill

Based on the coastal ecology around the Cape Three Point area (sandy and rocky shores), in the event of oil spillage, the marine organisms which inhabit or occasionally use these ecosystems would be much impacted. Among these organisms include turtles, crabs, bivalves and gastropods in the sandy shores and macro algae, barnacles and littorinid snails in the rocky shores. Ecologically, the algae mats serve as micro-habitats for epifauna (crustaceans and invertebrates), and fish (Armah et al, 2004).

A stochastic modeling conducted by Reynolds et al (2009) to assess the potential marine gasoil and crude oil spills from the Jubilee Field within the Deep Water Tano and West Cape Three Points Blocks revealed that 'the footprint for the area of potential impact varies with spill size, with the maximum length of the footprint ranging from 40 km for a marine gasoil spill of 10 Tonnes to more than 600 km for crude oil spills of 1000 Tonnes or more'. Roughly 200-300 km of shoreline was assessed to be at risk for oiling with the larger spill sizes having the potential for more shoreline impact. The shoreline with the highest probability of being oiled was the 100 km west of Cape Three Points. East of Cape Three Points, a longer reach of shoreline, could potentially be oiled, but the probability of oiling was generally less than 10 percent.

Considering the total stretch of Ghana's shoreline of about 550km from the border of Cote D'Ivoire to the border of Togo, the worst scenario of crude oil spill could cover up the entire shoreline. In the case of the Exxon Valdez, oil traveled some 600 miles (1,000 km) from the site of the spill, and ended up oiling some 1400 miles of shoreline. This implies the numerous ecosystem services being provided along the coastline of Ghana are all at risk. Among the important ecosystems on the shores of Ghana include coastal lagoons, estuarine, and mangroves. Armah et al (2004) revealed that 'there are more than 90 lagoons along the entire coastline of Ghana and this includes about 26 open lagoons. The open lagoons are mostly found in the central and western coastline encompassing the Cape Three Point area. These lagoons serve as habitats for a variety of fish, shrimps, mollusc, and crabs species and they also serve as nursery sites for these organisms particularly for juveniles of marine fish and shrimps. Economically, these lagoons are a source of income to the local fishermen. Moreover, some lagoons are wintering sites for Palaearctic birds as well as roosting sites for local waterfowls (Armah et al, 2004). Five of the lagoons are designated Ramsar sites namely the Sakumo, Densu, Muni-Pomadze, Keta and Songor. These sites are though quite far from the Jubilee Field, a worst scenario of oil spillage could affect all these areas.

The impact of oil spill on the coastal ecosystem of Ghana depends on a number of factors. These may include the type and amount of oil and its behavior once spilled; the physical characteristics of the affected area; weather conditions and season; the type and effectiveness of the clean-up response; the biological and economic characteristics of the area and their sensitivity to oil pollution. Typical impacts of oil spill range from toxicity (especially for light oils and products) to smothering (heavier oils and weathered residues). The impact of oil spill on marine species

may include: (a) damage to the digestive tract and other organs through digestion/absorption of oil in contaminated food (b) inflammation and infection (c) contamination of eggs leading to poor hatchery success (d) trapping of newly hatched turtles leading to death.

4.3.2 Socio-economic impact of the jubilee field project

The Jubilee Field's oil and gas exploration and production come with many indirect impacts on the coastal dwellers, which are of socio-economic characteristics. Among them include:

4.3.2.1 Fishery

One of the ecosystem services derived from the coastal waters of Ghana is food mainly in the form of fish. As such, fishing is the main source of occupation among the coastal dwellers. However, restrictions around the jubilee Field concession zone means denial of access to these fishermen. This coupled with pollution (from drill muds), increased in sea traffic and oil spillages from the project have a tremendous negative consequence on the catch volumes of fish. In a study on the Barents Sea, Engas et al (1993) reported that during shooting of seismic guns, catch in the shooting area decreased by 60% and catch in the other areas (up to 18 km from the exploration area) decreased by 45-50%. Catch rates did not recover during the 5 day period after shooting ended. The long line catch decreased by 45% in the exploration area, but the decline was smaller with increasing distance from the exploration area; with no reduction in catch at distances beyond 16-18 nautical miles.

In Ghana, fish is the single most important low cost animal protein source in the country and accounts for about 60-70 % of the total animal protein intake by the average Ghanaian. A substantial part of this fish intake is derived from the country's marine capture fishery, whilst aquaculture contributes only a small percentage (Armah et al, 2004). Also, it is estimated that the fishery subsector employs at least 500,000 fishermen, processors, traders, mechanics and boat builders who together support twice as many dependants. Bannerman et al (2001) reported that the coast of western region alone has 94 landing sites, 2731 canoes and 24358 fishermen. Considering such a dependence on the fishery industry, a reduction in catch volumes as a result of the oil and gas exploration has a tendency to give rise to insecurity and strife due to poverty generated by the collapse of the fishing industry. Already, some representatives of fishmongers from the nearby communities have expressed worry over recent low fish harvests blaming it on the rig. Incidentally, it seems the fish have taken cover in areas close to the rig, making it difficult for the fishermen to get them without incurring the displeasure of the navy that patrols Ghana's territorial waters. According to them, this has resulted in losses which in turn have rendered them incapable of repaying loans they took from the banks (Allafrica, 2009)). Meanwhile, there is no regulation granting fishermen's accessibility to fishery resources in such situations. But, section 93 of the Fisheries Act 625 (2002) requires that the Fisheries Commission be informed of any activities with substantial impact on fishery resources and also recommendations to minimize or prevent impacts on fishery resources. This regulation seems not to have been followed.

4.3.2.2 Human health

One of the potential impacts identified with the oil and gas exploration in Ghana is the release of toxic and obnoxious materials into the environment. Heavy metals from the drilling and production activities contaminate the marine ecosystem leading to a possible accumulation in marine organisms. By bioaccumulation, the toxic chemicals enter into the food chain and their effects may not be immediately conspicuous but chronic in humans. Wild (1996) and Population Reports (2000) indicate that the most dangerous heavy metals with serious human ill-health include lead, mercury, cadmium, arsenic, copper, zinc and chromium. Cadmium and arsenic, for instance, are reported to cause cancer whilst exposure to lead was reported in a study in Thailand, to possibly cause about 70,000 children to lose four or more points of intelligences Quotient (1Q) (Population Reports, 2000). Similarly, the UNDP (1998) reported that about 15 million children from the Latin America under the age of two were at risk of ill-health due to lead pollution. These reported pollutants are also released into the environment by the oil and gas activities. A typical situation for contamination is the absence of toxic waste treatment facilities in the western region which makes the open municipal dumping place a target. At the on-site of operations in most oil fields, the release of hydrogen sulphide gas (H_2S) is not something uncommon. This gas is reported deadly at relatively low concentrations and the effect is instant. A relatively short-term exposure to 500-1000ppm can be life-threatening and can cause serious harm whilst repeated exposure to lower concentrations causes conjunctivitis, photophobia, corneal bullae, tearing, pain and blurred vision.

In spite of the direct ill health associated with the oil and gas industry there are others that are indirectly caused by the industry. For instance, the western region of Ghana is posed to attract a number of people from all walks of life for job opportunities. Inclusive in this group of migrants are sex workers. This category of people is likely to increase the prevalence of HIV-Aids and other sexually transmitted diseases in the region. Also, drug addiction is likely to increase in the region since such a situation has characterized similar oil and gas producing cities/town throughout the world. The situation perhaps is more worrying in Ghana due to its inadequacies in law enforcement as well as poor capabilities or facilities to deal with such menace.

4.3.2.3 Social pressures and other secondary impacts

An increment in local population as a result of migration for job opportunities implies extra pressures on schools, hospitals and recreational facilities. Additionally, the situation has a tendency to give rise to urban slums due to poor planning. A typical example is seen in Gabon where Shell oil's operations have served as a catalyst for the establishment and development of the Gamba town. Here, the situation has led to encroachment on nearby forest for bush meat and limited farming; thus destroying the biodiversity. In Ghana's situation, an increment in local population particularly in Takoradi and Sekondi will necessitate provisioning of accommodation to cater for the teeming population. Such a situation may lead to clearing of vegetation for such projects, but not without environmental consequences. A typical example is already seen in the mining communities of Obuasi and Tarkwa where vast fertile lands have been cleared for

building projects for mining workers. Meanwhile, the western region hosts one of the richest conserved areas, Ankasa, hence an encroachment of any scale would have negative consequences on biodiversity.

The oil and gas discovery is likely to bring about a vibrant economic life in Takoradi and Sekondi cities. Such a situation may trigger a corresponding increment in road traffic especially between Accra and Takoradi-Sekondi. At the moment, some infamous accident-prone roads in Ghana have been identified along the Accra-Cape Coast-Takoradi highway. These areas include the Winneba-Kasoa-Accra road, which falls into the main highway of Accra-Takoradi. In effect, an increment in road traffic will only increase the probability of road accidence. This may not be the situation on the highways alone but within the cities of Takoradi and Sekondi as well. In case the traffic pressures are localized within the cities, the need to construct new roads may become essential. But such constructions also come with environmental costs especially when plants are cleared to pave way for road construction.

Another indirect effect may arise from a shift in employment from agriculture to oil related jobs due to salary differences. At the moment, the western region is the leading producer of cocoa, oil palm and rubber for export and local consumption. Also, most of the country's foodstuffs for local consumption come from the region. In this view, any reduction in the agricultural workforce will not only affect the local food supply but will also affect the nation's earning on foreign exchange especially when the impact is felt on commercial crop productions.

4.4 Analysis of Ghana's ability to cope with the threats from the oil and gas industry

Ghana's quest to safeguard the environment is manifested in the establishment of the environmental protection agency (EPA) since 1994 with powers to regulate the activities within the environment. As revealed earlier in section 4.2, the number of legal frameworks for the fishery division and also for ecosystem protection could help avert the extreme impacts of oil and gas exploration if well implemented. Administratively, the nation's style of environmental governance is more tuned to a top-down approach. As such, the basic policy instrument is 'command and control' approach and that involves compliance to laws (regulations), environmental standards and guidelines. On that ground the EPA has since its inception been using the Environmental Assessment Administration procedures as its major tool for achieving compliance with its legislation. Under the procedure: (a) new developments are to register with the EPA, conduct an environmental assessment of their proposals and submit an environmental assessment report to the EPA for review. There are levels of assessment depending upon the type, scale and location of the activity. Environment Permit is granted for the development to start when EPA is satisfied with the assessment conducted and the mitigation measures (b) industries in existence before the legislation are to conduct an environmental assessment of their facility and propose ways and means of improving the level of performance of their set-ups. These Environmental Management Plans are then submitted to the EPA for review. The

commitments made by the management of the set-ups are to be implemented and the goals achieved within three years, after which another plan must be submitted. The new industrial set-ups are also required to comply with this procedure after 18 month in operation (c) industries are also requested to submit monthly returns of their environmental parameters monitored to the EPA. Comments are also expected in cases where values exceed certain limits and what measures are in place to check the discrepancy (d) industries are also requested to submit Annual Environmental Report to the Agency, indicating how they have performed environmentally, what have been achieved, what went wrong and what needs to be done. The EPA then measures environmental compliance based on the number of applications received for environmental permits within a certain time frame.

The objectives of these laws are justified and relevant to the needs of the coastal environment and the society as a whole. However, the inputs in terms of human, capacities and financial resources, which are needed to accomplish these objectives, are limited and inadequate. In the following section, I look at the adequacy of current environmental guidelines in Ghana and how they are being enforced and monitored.

4.4.1 Ghana's Environmental Standards and Guidelines

The existing ambient air quality guidelines in Ghana have been carefully crafted from major international environmental standards and guidelines making the Ghanaian standards quite robust (see Appendix 1). Notably among these international standards include the World Health Organization's (W.H.O) guidelines, International Finance Company (IFC) and the MARPOL convention. The guidelines though fall short of the World Health Organization's guidelines they are apparently robust than that of the United States especially for pollutants SO_2, NOx and PM_{10}. Considering the United States' health records, living standard and experience in oil industry, it would have probably been more logical to expect the US to have a tighter standard. But despite the impressive figures of Ghana's ambient air quality guidelines, there are still problems especially when ambient is used as a measure in oil and gas exploration and production. Where measurements should be taken relative to the point of emission is a question currently not addressed by the ambient air quality guidelines of Ghana. Moreover, there is no distinction regarding measurements on-site and off-site; but the oil field workers and coastal dwellers are exposed to different ambient concentrations at different times daily. The absence of such provisions has serious repercussions on data gathering and monitoring which could be easily exploited to the advantage of the oil and gas companies.

Another worrying situation in Ghana is the existence of effluent standards but absence of emission standards especially for aerosols. Even with the effluent standards for discharge into water bodies, there is still a problem as to how certain measurements should be taken. For instance, the guidelines specify that effluent temperature should not increase the ambient temperature of the receiving environment by 3^oC but it is not explicit enough as to the distance or edge of the zone where measurements should be taken relative to the point of discharge.

Obviously, a few feet from the point of discharge would have elevated temperatures than a few meters away. The IFC though proposes an edge of 100m distance from the point of discharge in situations where the edge is not defined.

In view of the above mentioned problems: undefined on-site and off-site ambient guidelines, absence of emission standards, inexplicit definitions on how measurements should be taken; I consider Ghana's guidelines inadequate to deal with the environmental threats imposed by the offshore oil and gas development.

The MARPOL convention deals with issues of coastal pollution and spells out guidelines for managing effluents or discharges from ships. Ghana being a signatory to the MARPOL Convention has so far ratified the first two mandatory annexes i.e. the Regulations for the Prevention of Pollution by Oil *(Annex I)* and Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk *(Annex II)*. These should help minimize ship pollution related to the offshore oil and gas activities if the guidelines are strictly adhered to. However, since Ghana has not yet ratified the last four annexes: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form *(Annex III)*, Prevention of Pollution by Sewage from Ships *(Annex IV)*, Prevention of Pollution by Garbage from Ships *(annex V)*, and Prevention of Air Pollution from Ships *(Annex VI)*; it is still unclear how the oil and gas exploring companies intend to apply these last four annexes to deal with garbage, sewage, and ship's air pollution as contained in the environmental impact statement issued by the oil and gas exploring company (Tullow Oil).

4.4.2 Law Enforcement

Ghana's EPA has two sub departments namely the Environmental Inspectorate and Legal departments of the Agency, which are merged together to deal with non-compliance of the regulation. However, as always been the problem with 'command and control' as a policy instrument, implementation gap has been the most challenging issue facing the country. For that matter, the nation has failed to adequately enforce and monitor regulations. The existence of implementation gaps in Ghana is attributed to the fact that ensuring compliance is time consuming and costly. Also, it requires capacity establishment (law enforcement agencies), huge resources, coordination, clear lines of responsibilities, and political will. These the nation could hardly afford till date and for that matter most projects are not subject to the strictest procedure as demanded in the regulation. For instance, the section 92 of the Fishery Act 625 (2002) prohibits the pollution of water that may have an adverse effect on aquatic resources. The law, specifically section 93, makes it a mandatory for the Fishing Commission to be informed of any activities likely to have substantial impact on fishery resources before commencement of the activity. The Fisheries Commission then has the right to require reports and recommendations by the proponent on the likely impact of the activity and possible means of preventing or minimizing adverse impacts, which shall be taken into account in the planning of the activities. Moreover, the Environmental Assessment Regulations, 1999 (LI 1652) within the Environmental Protection Act (Act 490 of 1994) require that an Environmental Impact Assessment (EIA)

process be undertaken. Specifically, all activities likely to have an adverse effect on the environment must be subject to environmental assessment and issuance of a permit before commencement of the activity. So by law, Ghana's Environmental Protection Agency (EPA) could not have issued any permit for oil and gas development or the construction of oil and gas separation, processing, handling, and storage facilities without the submission by the companies of an environmental and social impact assessment (ESIA) in accordance with regulations; yet the companies managed to undertake their activities without fulfilling the prerequisite. Important to note is that the exploration drilling and other related activities offshore Ghana commenced in 2007. A statement: ‘’everyone admits that the companies (oil and gas exploring companies) have not submitted a full ESIA to the government’’ by Bretton Woods (2009) in the early part of 2009 perhaps better confirms this assertion. Finally, when the environmental impact assessment (EIA) arrived in July/August 2009, there were missing details on key environmental and social issues. This situation represents the first flaw of the law, which somehow set precedence for companies to undertake their activities with impunity. The core of this problem might have been due to the fact that economic (monetary) benefits were prioritized against any environmental and social consideration as far as this project is concerned. However, compromising the environmental and social considerations also has serious negative economic repercussions, which may lead to conflicts with the local stakeholders. In the end, the conflicts may be more costly economically than the derived monetary benefits.

The Fishery Acts 625 (2002) section 92 sanctions $50,000 and $ 2million as minimum and maximum fines respectively for any person who directly or indirectly introduces deleterious substances into fishery waters. This is quite a deterrent, however, since the inception of the law no individual or company has been found guilty of such an offence. Meanwhile companies continue to pollute water bodies and the environment as a whole. A typical example is seen in the gold mining companies, which continuously pollute water bodies yet face no legal charges. With this as background, it is perhaps reasonable to deduce that similar situation will happen with the oil and gas exploration as well.

4.4.3 Monitoring

The Ghana National Petroleum Corporation Act (Act 64 of 1983) empowers GNPC to effectively monitor the operations of the oil company and apply sanctions through the Minister for Energy. The Law empowers GNPC to attach its officers to operations during all phases of operations. Similarly, the Law provides for GNPC to arrange for Customs officers on the production facilities and production platforms to monitor metering and production operations to verify quantities of oil and gas produced and lifted. Before any oil is lifted and sold from the facilities, the Customs officers will have to certify the quantity and quality of crude. The monitoring provisions in this law are more related to assessing production quantities and qualities of crude oil and not much relevant to the environment. By the Environmental Assessment Regulations 1999 (LI 1652), industries are requested to submit monthly returns of their environmental parameters to the EPA so are they requested to submit Annual

Environmental Report to the Agency. Here, since the companies themselves are to report on their discharges, it is not certain if the right figures (exact parameters) will be submitted. Besides, any visit by the EPA to the operation site must be planned with the companies. This somehow gives signals to companies to properly arrange things or cover up issues prior to the visit.

In a way, the IFC has also not been helping as far as environmental issues on Ghana's Jubilee project are concerned. For instance, as a requirement the IFC is mandated to demand compliance to national regulations before financing companies. The international recommendation is that plans for oil and gas exploitation and plans to protect the marine environment should be developed within the context of national sustainability strategies as recommended at both the Rio (1992) and Johannesburg (2002) World Summits on Sustainable Development (WSSD). However, it is astonishing that the oil companies somehow managed to secure loans from the IFC even when the EIA was not yet ready. Such a practice is definitely against the ethics of international communities and casts blur on international monitoring of major projects of environmental concern.

4.5 Recommendations to minimize the impacts of Ghana's oil and gas exploration

Based on this study, the following recommendations are proposed to help curb the environmental and socio-economic impacts of Ghana's offshore oil and gas exploration and production:

4.5.1 Short-term measures

There is the need to establish a detailed baseline data on wildlife availability within the project area. At the moment, data is dispersed in literature but baseline information could help in cost-benefit analysis especially if the impacts are to be assessed in monetary terms. Also, such a data could help in future investigations.

There is also the need to monitor and investigate reductions in fish catch volumes especially the comparison of ante and post project phases. This will help evaluate the real impact on the fishery industry so that appropriate policies can be put in place to minimize the effects on the fishermen.

Moreover, environmental data concerning the oil and gas exploration and production should be made public. In other words, there should be freedom of assess to information. This should be legally binding to all the oil and gas exploring companies.

Furthermore, flying over nature reserved areas should be avoided to prevent noise disturbances to birds. If so necessary that flying be done over these areas, then mandatory flying height limits should be applied. This is important because the estuaries along the Cape Three Coast are often used by birds. Also, the Ankasa conservation area is not far from the operational field.

Finally during seismic surveys, licensees should be required to implement a policy to reduce the risk of auditory trauma to marine mammals and sea turtles. The policy should include the following provisions:

- **Soft start** – Every time the use of the seismic array is initiated, "soft-start "procedures should be used to allow time for marine mammals and turtles to move away before the array reaches full power. The process should begin with the smallest source in an array and build up slowly over 20 to 40 minutes

- **Visual monitoring** – Beginning at least 30 minutes before startup during daylight hours, visual observers should monitor a safety (exclusion) zone of 500-m radius around the source vessel. Startup of the array cannot begin until the safety zone is clear of marine mammals and turtles for at least 20 minutes

- **Shutdown of the array** – Visual monitoring of the sea surface should continue while the seismic array is operating during daylight hours, and the array should be shut down if a whale, monk seal, or sea turtle enters the safety zone during visual monitoring.

4.5.2 Long-term measures

One of the problems identified under this thesis is the poor capacity of Ghana government to enforce and monitor environmental standards and guidelines. This situation is attributed to the fact that there is a hierarchical kind of environmental governance and authority for such task (enforcement and monitoring) is left in the hands of the environmental protection agency. But the multi-billion oil companies can easily corrupt the staff of the EPA. So to act as whistle blowers, there is the need to strengthen the various environmental non-governmental organizations (eNGOs) in Ghana to undertake their own investigations on-site so as to scrutinize any misdeeds of the EPA. Also, the traditional councils in the impacted areas should also be part of the monitoring and reporting on the effectiveness of the Environmental Management Plans.

Also, the governments of the West African marine and coastal eco-region could adopt the concept of a comprehensive regional convention for offshore oil development. This convention should reflect the specific needs of the region and the vulnerability of the local ecosystem. Involving a large range of stakeholders will be critical to establish regional standards. A citizen council in which representatives of key stakeholders are united may provide governments with a workable framework for effective stakeholder consultation (Kloff and Wicks, 2004)

It is established in this thesis that some fishermen are bound to lose their livelihood due to low fishery activities, which come along with the oil, and gas exploration. To minimize such impacts on the coastal dwellers, there is the need for oil and gas companies to sign social responsibility agreements with their catchment communities. This may involve an establishment of inland aquaculture and other income generation activities to get these people employed.

Additionally, there is the need to establish a citizen advisory council as being practiced in Alaska. This in a way conforms to international recommendation that government and oil industries actively involve major stakeholders in order to deal with complex environmental issues. The citizen advisory council is a participatory approach to offshore development where conscious effort is made to gain valuable information regarding functioning, vulnerability and management of marine ecosystem. The stakeholders may include fishermen, tourism operators, scientist, and conservationists. In Alaska, the members of the council participate in decision-making procedures, an important role in law enforcement. All members have guaranteed access to oil facilities and have the funding from the oil companies to undertake independent evaluations, ecological monitoring and to hire independent expertise. Such a practice in Ghana can avoid a lot of the mistakes that have been made in the past particularly in most oil rich African countries.

Finally to avoid long term transboundary pollution problems with neighboring countries, there is the need to initiate the process of establishing pollution deposition models e.g. RAINS, to bring sanity within the West Africa region. This is important in view of the upsurge in oil and gas exploration activities within the gulf of guinea. Currently, there are on-going oil and gas exploration activities in the coast of Cote Dívoire, Nigeria, Ghana, Gabon and Angola. Many nations are yet to join the race of exploration, which could trigger a massive air pollution problem within the region.

4.5.3 A summary of Impacts and recommendations

The table 2 below gives a summary of pressures or issues from the oil and gas exploration and production, the existing regulation measures and the proposed measures to curb the impacts.

Table 2: Pollutants/Pressures, current regulations and proposed measures

Issue	**Impact Description**	**Existing regulation measure**	**Proposed Mitigation measures**
Seismic and operational noise	Auditory trauma to marine mammals and sea turtles (including endangered, critically endangered, and vulnerable species)	No regulations exist	Licensees should be required to implement policies which should include soft start, visual monitoring and shut down of operational engines.

Issue	Impact Description	Existing regulation measure	Proposed Mitigation measures
Ship discharges including produced water, ballast water, bilge water	Impacts on water quality affecting biodiversity	MARPOL Compliance. Also effluent discharge guidelines are available.	No mitigation measures are proposed
Air pollutant emissions	Impacts of air quality	MARPOL Compliance but Ghana has not yet ratified annex VI	No mitigation measures are proposed
Physical disturbances	Disturbances to seabed as results of drilling and installations. Effects on deepwater corals and benthos ecosystems	No regulations exist	Oil and gas companies should be required to evaluate project area for deepwater corals and chemosynthetic communities Licensees should as well maintain a separation distance of at least 100 m between any potential deepwater coral or chemosynthetic communities and any sea floor disturbances (including anchoring) within the activity footprint
Drilling discharges including drill mud and cuttings	smothering effects on deepwater corals and benthos ecosystem	No regulations exist	Oil and gas exploring companies should be required to evaluate project area for potential presence of deepwater corals and chemosynthetic communities, and maintain a separation distance of 500 m from any drilling discharges

Issue	Impact Description	Existing regulation measure	Proposed Mitigation measures
Support activities	Helicopter operations	No regulation exist	Flying over nature reserved areas should be avoided to prevent disturbances to birds. If so necessary that flying be done over these areas, then a mandatory flying height limits should be applied.
Oil Spills	Impact depends on the quantity but the effects may include: poor water quality; death or injury of marine mammals, turtles, and birds; contamination of coastal habitats including beaches; and interference with fishing, shipping, recreation, and tourism during response and cleanup operations	MARPOL Compliance. Annex I requires Shipboard Oil Pollution Emergency Plan	A comprehensive oil spill trajectory modelling should be conducted to aid in understanding the fate of an oil spill at various locations in the licence area, the potentially affected environmental resources, and minimum response times.
H_2S release	Potential death or injury of humans on offshore facilities and adjacent waters; potential death or injury of wildlife including birds	Ambient Air Quality guidelines exist (See Appendix 1)	Licensees should be required to submit information on expected H_2S levels for prospective drill sites.. Where there is a significant risk of encountering H_2S during operations, licensees should be required to submit an H_2S Contingency Plan

Issue	Impact Description	Existing regulation measure	Proposed Mitigation measures
Vessel traffic and restricted access e.g. the rig	Potential conflicts with fishing or shipping activities	Fisheries Act 625 (2002) requires that the Fisheries Commission be informed of any activities with substantial impact on fishery resources.	Oil and gas exploring companies should have regular consultations with the local fishermen so as to address their concerns. An establishment of citizenry advisory council could help overcome this problem.
Transboundary problems	Impacts on connected ecosystems within the coast of Gulf of Guinea. Transboundary air pollution problems	Ghana is a party to 1972 Stockholm Convention. The Principle 21 prevents transboundary pollution.	As a long term measure, the governments of the West African marine and coastal eco-region could adopt the concept of a comprehensive regional convention for offshore oil development. This convention should reflect the specific needs of the region and the vulnerability of the local ecosystem.

5. DISCUSSIONS AND CONCLUSION

5.1 Uncertainties

This thesis is mainly based on secondary data but probably not all relevant data regarding this research were obtained. From literature review, it was clear that there are currently no emission standards and guidelines in Ghana apart from the existing ambient air quality and effluent guidelines. Also, the acquired literature reveals absence of measurement zones or peripheries regarding how ambient measurements should be taken relative to the point of emission. Perhaps, these documents exist but simply could not get hold of them. More so, there is currently lack of baseline data especially on the coastal ecosystem services and marine organisms within the waters of Cape Three Point where the oil and gas exploration is currently taking place. Literature on cetaceans in Ghana and the Gulf of Guinea are few and the distribution, natural history and conservation status of most marine organism remain understudied. The limited information presents uncertainties in that it may introduce inaccurate analysis and assessment of impact on these organisms. For instance, an oil and gas exploration activity may be considered a minor impact but in reality could be a major impact if the organisms within the area were known.

Additionally, there are vast uncertainties in literature regarding the impact of noise, light, discharges, and emissions on the coastal ecosystems and biodiversity. Various researchers differ as to the quantity or intensity of these pollutants to be considered deleterious to marine ecosystems and biodiversity. For instance, whilst some researchers consider noise a deleterious to fish, others differ on the reason that fish lacks the organs for hearing

5.1.1 Dealing with uncertainties

To deal with such uncertainties, data were obtained from different possible sources (triangulation of sources) especially from institutions related to environmental regulations. Numerous literatures were studied and the common views shared by the majority of researchers were considered in this research. On Ghana's emission standards, available literatures in Ghana were thoroughly studied if there had been some citations or references to Ghana's emission standards. Also, different experts' views were sought on the subject and the common view across experts was considered in this thesis.

5.2 Main Conclusion

This thesis sought to investigate and analyze the potential impacts of Ghana's oil and gas exploration and production on its coastal zone. The focus was actually on the impacts on ecosystem services and how these affect the socio-economic situation of the coastal dwellers. The results presented and discussed in chapter 4 show that the degree of impacts depends on a number of factors among which include the stage or phase of production, the size and complexity of the project, and the sensitivity of the surrounding environment. Also, the effectiveness of planning and mitigation techniques could either exacerbate or assuage the impacts. On the basis

of time of occurrence, this thesis categorizes the impacts as first order, second order and third order.

The main conclusions drawn from this thesis are as follows:

1. ***Noise, discharges, emissions and physical destruction from the oil and gas exploration and production have negative impacts on Ghana's coastal ecosystem services and biodiversity***

In table 1, the exploration through to the development and production phases are associated with pollutants which include noise (sound), CO_2, CO, SO_2, NOx, H_2S, heavy metals; Ba, Cd, Zn , Pb; Benzene, radioactive materials , sewerage and domestic waste. These pollutants initially give rise to the first order of impact and with time the second and third order may become manifested. The pollutants have been shown to have detrimental effects on the marine biodiversity. For instance, most of the tools and equipment associated with the oil and gas operations are capable of generating noise to magnitude between 120 and 220 (dB re 1 μPa at 1m). These values are reported to trigger behavioral response in most marine organisms particularly cetaceans which rely on sound for many functions (see McCauley, 1994). Such behavioral responses may occur at far distances from the original point of occurrence. But, it is revealed that the waters of Cape Three Point are used as a migratory route for most of these marine organisms and that any avoidance behavior triggered by the oil and gas exploration activities could cause a route diversion. The consequence is that Ghana (and possibly the entire sub-region including Cote D'Ivoire) may be losing on tourism since the existence of such migratory route could have been explored for eco-tourism purposes. Other discharges could either have direct effects on the marine ecosystems or could trigger secondary impacts especially when particles are suspended in the water. Notable direct effect of discharges is the physical smothering of biodiversity particularly the benthos species as a result of drill cuttings deposition. Also the physical destruction of seabed may leave a permanent loss of habitats for benthos biodiversity. Eventually, the suspended particles negatively affect the water quality thereby causing respiratory related problems to certain species.

2. ***The oil and gas exploration and production imposes socio-economic challenges to the dwelling coastal communities***

The FPSO and MODU together with the increase in ocean traffic bring its own environmental and social challenges. For instance, ships may introduce non-native species, which with time may become a canker that may demand huge resources to fight. These facilities also in one way or other interfere with the operations of local fishermen thereby denying them access to operational areas and consequently denying these fishermen of their daily livelihood. Such a situation has a tendency to bring about conflicts between the oil and gas companies and the local dwellers since most of them earn their living from the fishery industry.

Additionally, the oil and gas exploration and production has the potential to cause prevalence of diseases e.g. sexually transmitted diseases (STDs) due to the fact that the region is poised to

attract migrant workers and inclusive in this category are sex workers. In areas of similar oil and gas exploration and production activities in Africa, STDs and drug addiction usually characterize the communities.

Moreover, the region is bound to experience population explosion, which could cause undue social tensions such as pressures on schools, hospitals and roads. Such tensions may trigger secondary impacts because large areas of vegetation may have to be cleared in order to build more facilities to meet the demands of the local population. Such constructions meanwhile, have negative consequences on ecosystems and biodiversity especially when the western region is considered the magnate of biodiversity in Ghana.

As the oil and gas industry becomes attractive, more people are likely to abandon fishing and farming in the region. But these traditional jobs have sustained the local communities and contributed immensely to Ghana's economy for ages. Abandoning such jobs could impact negatively on other sectors of the economy especially the agriculture and fishery industry. The real effect may not be immediately conspicuous but known after the oil and gas project is over or decommissioned. Such a situation necessitates the need to utilize the oil and gas revenue to develop other sectors of the economy.

3. *Ghana lacks the capacity to monitor and enforce compliance to environmental legislation*

Despite the above-mentioned potential impacts from the oil and gas development, it is revealed in this thesis that although Ghana has the appropriate legislation framework, there is still an existing problem of implementation gap which affect monitoring and law enforcement. Ghana till date has not been able to properly enforce environmental compliance due to the associated cost in terms of capacity establishment, resource and logistic demand. Also, there are no clear lines of responsibilities and lack of political will. Such a situation has led to situations where the environmental impact assessment is conducted long after the project had commenced. This situation is also seen in the current oil and gas exploration and production since the environmental impact statement was presented almost two years after the program had commenced.

4. *The existing environmental guidelines and standards in Ghana are inadequate to cope with the environmental threats from the oil and gas exploration and production.*

Currently, Ghana has no emission standards for aerosols but these are necessary if the oil and gas exploring companies are to be serious with their emissions. Such emission standards have the advantage to compel the oil and gas exploring companies to opt for the best available technologies in order not to attract penalties. The existing ambient air quality guidelines do not specify on-site and off-site requirements. Also, just as the effluent guidelines, the ambient standards are not explicit as to the edge or zones of measurement. For instance, there is still a question of which distance to take ambient measurements.

5.3 Recommendations

5.3.1 Recommendations to minimize impacts of Ghana's offshore oil and gas exploration

The recommendations to minimize impacts from the offshore oil and gas development in Ghana are already dealt with in section 4.5. However, they are summarized in the following tables:

Table 3 Short and long term measures to minimize impacts from Ghana's oil and gas development

Short-term measures	Long term measures
Establishment of baseline data	Empowerment of eNGOs
Investigation into reductions in fish catch volumes	Adoption of regional marine convention for offshore development
Public access to environmental data on the O&G development	Commitment to social responsibility agreement with catchment communities
Avoidance or maintenance of a mandatory flying height over conserved areas	Establishment of citizen advisory council
Adoption of **short start**, **visual monitoring** and **shut down** engine policy	Commencement of a model to deal with transboundary air pollution problems due to proliferation of oil exploration activities along the coast of Gulf of Guinea.

5.3.2 Recommendations for further studies

Based on this thesis, the following recommendations are made for further studies:

(a) There is the need to thoroughly investigate the problems of environmental impact assessment (EIA) within the Ghanaian administrative systems. This is necessary because despite the existence of legislation for a mandatory environmental impact assessment before commencing projects, companies still manage to conduct such assessment half-way through the project cycle. By then, it may be too late and more costly to terminate such projects. Perhaps, the system is not working.

(b) There is the need for studies to be conducted on the impact of the oil and gas exploration and production on the total fish catch volumes. This may be a comparison of before-project-catch volumes and after-project-catch volumes. Such a study is essential to establish the real impact on the local fishing industry and also for recommendations to prevent conflicts. Similarly, a study may also be necessary to ascertain the real impacts on cetacean route diversions especially a comparison of before and after project.

(c) There is the need to quantify these impacts for trade-off analysis based on monetary values. This is necessary because such projects are often conducted with much priority on the revenue to be generated. Meanwhile, the environmental repercussions in monetary terms may far outweigh the revenue.

(d) More studies should be conducted on the socio-economic impacts of the oil and gas project on the local communities and perhaps Ghana as a whole. This thesis is not detailed enough especially on the impacts on local businesses, salary differentiation and the micro-economic situation of the local communities.

(e) There is the need for studies on appropriate emission standards for Ghana's environment taking into account the sensitivity of Ghana's ecosystems. Similarly, there is the need for a thorough study to address the uncertainties in taking ambient measurements.

(f) Studies should be conducted on making environmental impact assessment work in Ghana in spite of inadequate resources, capacities and inputs.

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APPENDICES

Appendix 1

Comparison of Ambient Air Quality Guidelines of Ghana and major International Guidelines (Based on the W.H.O, USA and Ghana guidelines)

Pollutant	**WHO**	**USA**	**Ghana**
SO_2 ($\mu g/m^3$)	20 (24-hr av.)	365 (24-hr av.)	150 (24-hr av.) Industrial 100 (24-hr av.) Residential
NO_2 ($\mu g/m^3$)	40 (annual av.) 200 (1-hr. av.)	100(annual av.)	400 (1-hr av.) Industrial 200 (1-hr av.) Residential
$PM_{2.5}$ ($\mu g/m^3$)	10 (annual av.) 25 (24-hr av.)	15 (annual av.) 65 (24-hr av.)	- -
PM_{10} ($\mu g/m^3$)	50 (24-hr av.)	150 (24-hr av.)	70 (24-hr av.)
CO (mg/m^3)		10 (8-hr av.)	10 (8-hr av.)
H_2S ($\mu g/m^3$)	150 (24 hours)	0.03 (1 hour)	150 (24 hours)

Appendix 2

Comparison of Effluent Quality Guidelines for discharges into natural water bodies-Maximum permissible levels- of Ghana and the IFC (Based on Ghana and IFC guidelines)

Pollutant	**IFC**	**Ghana**
pH	6-9	6-9
BOD_5 (mg/l)	25	50
COD (mg/l)	125	250
TSS (mg/l)	35	50
Oil and Grease (mg/l)	10	10
Cd (mg/l)	0.1	0.1
Total residual Cl (mg/l)	0.2	-
Cr (mg/l)	0.5	0.5
Cu (mg/l)	0.5	5
Fe (mg/l)	3	10
Zn (mg/l)	1	10
Temperature	$<3^oC$ above ambient level	$<3^oC$ above ambient level
Pb (mg/l)	0.1	0.1
Ni (mg/l)	1.5	-
Heavy metals (Total) (mg/l)	5	-
Phenol (mg/l)	0.5	2
N (mg/l)	40	50
P (mg/l)	3	2

Appendix 3

Ambient Noise Level Standards in Ghana (Adopted from Environmental Assessment Report of EPA, Ghana)

Pollutant		**IFC in dB (A)**	**Ghana in dB (A)**
Noise	Residential	Day time (07:00-22:00): 55	55-65*
		Night time(22:0007:00): 45	48-60)*
	Industrial	Day time (07:00-22:00): 70	70-75*
		Night time (22:0007:00): 70	65-70*

* ***Draft Ambient Noise Level Standards***