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Mitigating the Environmental Effects of Oil and Gas Exploitation: Issues of Compliance, Cost of Production, and Community Awareness

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Abstract

This study assessed the effectiveness of mitigation measures adopted to address the environmental effects of oil and gas industries from the perspective of compliance, cost of production, and community awareness. The research applied a case study through multi-method-qualitative and quantitative approaches. The target population of 547,368 people involved people in Takoradi, Shama and Newtown communities. A sample size of 150 was selected and categorised under 36% for Shama, 30% for Newtown and 34% for Takoradi. A combination of probability (simple random) and non-probability (cluster and convenience) sampling frames were used to access the respondents for the study. Data collection tools were limited to questionnaires and interview sessions. The descriptive statistics, Relative Importance Index (RII) and significance testing using a one-sample t-test module guided the analysis. Interview sessions were compiled into transcripts and later categorized into themes that directly reflected the patterns of the questions on the questionnaire. The conclusion rated major decisions in mitigating oil and gas impacts on the environment as first for conscious effort to package fuel and other chemicals in safe storages, followed by the use of best road systems to reduce the risk of accidents, then application of strict rules and regulations to curb impacts and lastly capacity building for participants in the oil and gas production industry. While significant measures have been adopted to mitigate the effects of oil and gas exploration, there remain challenges with effectiveness as a result of weakness in community involvement efforts, lack of motivation, weak laws and regulations and loss of respect. For effectiveness in reducing the challenges to mitigate the environmental impacts of the oil and gas production activity, policymakers, as well as the practitioners in the oil production industry, are advised to motivate people into buying into their policy to reduce such impacts.

Keywords

Mitigation, Environmental Impacts, Compliance, Production Cost, Community Awareness

1. Introduction and Literature Review

The extraction of oil and gas resources, including both onshore and offshore activities are vigorously pursued by the African States and international corporations because the resource continues to form a major share of global energy needs [1]. Developments in oil and gas exploitation on the global scene show a total of 3666 × 108 t (oil) and 301 × 1012 m^3 (gas) discovered reserves worldwide with 1474 × 108 t (oil) and 1187 × 1012 m^3 (gas) prospective resources [2]. The trend is similar to other perspectives, including in Africa where discoveries versus prospecting are 311 × 108 t (oil) and 26 × 1012 m^3 (gas), 184 × 108 t (oil) and 17 × 1012 m^3 (gas), respectively. The oil and gas industry in Africa continues to grow and attract many forms of investment, in many cases from China [3]. In the phase of these exploitations, the activities have unearthed arguments globally, questioning the justification to engage in oil and gas exploitation.

The benefits of oil and gas exploitation are inevitable; production could boost domestic gas production, lead to lower energy prices and improved energy security [4]. Economies with abundant oil and gas resources could sustain their growth path by creating opportunities for the wide-ranging use for oil and gas resources in the domestic economy [5]. This trend will lead to the expansion of domestic markets, an increase in the absorptive capacity of the economy, an enhancement in the effectiveness of factors of production, and the creation of conditions for technological progress, all of which are essential for the attainment of sustainable economic growth. For example, upstream oil and gas value chains, particularly firms within the same subsector of the Norwegian oil and gas industry are the beneficiaries of sophisticated and highly customised knowledge-intensive goods and business-to-business services as a result of being co-located [6]. Although the benefits of oil and gas exploitation are enormous, the adverse impacts of the related activities are also compelling and real.

The exploitation of oil and gas is known to result in varied impacts, including a considerable overlap of cost over benefits in Shale gas exploitation within the Romanian context [7], increased rate of environmental degradation with the potential to degenerate into food insecurity due to loss of fish and crops and ultimately loss in livelihoods [8]. In the Albertine Graben region of Uganda, an emerging oil economy, rent-seeking activities have resulted into speculative behaviour, competition for limited social services, land grabbing, land scarcity, land fragmentation, food insecurity, corruption, and ethnic polarization; with the consequent social impacts being considered by locals as a local resource curse [9]. The impacts of oil and gas exploitation have led to social conflicts

among the affected communities. In many cases of the environmental impacts of oil and gas exploitation, issues of compliance, cost of production and community awareness, have surfaced but received little scholarly attention.

Issues of compliance in oil and gas-related activities have become a major concern in many jurisdictions. [10] believed that experts can better understand oil and gas exploitation issues by exploring risks in regulatory, compliance, financial and reputation. They further argued that academic experts rate compliance as the second least important external force but, the third most important factor according to practitioners. In reducing the negative impacts of petroleum-related activities on the environment, compliance in terms of upholding Corporate Social Responsibility tenets is vital [11]. [12] also highlights the relevance of compliance that is provided through corporate responsibility, to protect human rights for the extraction of oil and gas production in Tanzania. In a related study, [13] think that, although African states have enacted legal regimes for the petroleum industry, there remains an increasing concern over the environmental consequences of the upstream oil and gas activities across Sub-Saharan Africa. The reason for the increasing impacts as argued out is a general weakness in legal and institutional frameworks for petroleum management. Therefore, there is the need for Environmental Impact Assessment (EIA) of mining projects to encompass the entire life cycle of the mine, incorporate the assessment of negative impacts and societal benefits also, and incorporate the liability and cost [14]. Responsible mining should, therefore, incorporate mining laws and legal and technical capacity that meet good mining procedures and conforms to the nest international standards. Linked to the environmental impacts of oil and gas exploitation is the mediating effect of the general cost of production in the petroleum industry.

Some literature argues that the magic to influence Sustainable Supply Chain Management in the oil and gas industry is the prevalence of economic and political stability [10]. In a related case, it was revealed that the general low subsurface complexity of the Nigerian oil and gas projects which calls for low technology challenges are advantages for field development; therefore, subsurface complexity and technology challenges are not the major causes of the poor performance, including those related to the adverse impacts of the oil and gas industry [15]. Another argument citing the cost of production of oil and gas and associated risks include the inherent risks of catastrophic oil wells blowouts at extreme depths which tend to increase as the productivity of oil facilities increases exponentially with water depth, as evident in the "Golden Triangle" between West Africa, Brazil and Gulf of Mexico [16]. Aside from the production cost, community awareness provides further knowledge to issues of mitigating environmental impacts of oil and gas production.

Lessons from [17] on the recent "shale boom" in the US highlighted the need for Mexico to inform mainly Mexican policymakers, but also key stakeholders such as academics, nongovernmental organizations, and the public in general,

about the main concerns regarding the importance of regulatory enforcement and community engagement to advancing sustainability. The need to incorporate good practices and awareness creation in EIA was identified by [18] as critical for addressing risk issues associated with the oil and gas industry in Myanmar. [19] periodic systematic reviews of the quality of submitted EIA show its potential to help highlight some of the underlying problems of, and solutions to, oil and gas activities and the related environmental impacts. Education level and environmental awareness are argued to significantly relate to risk perceptions (noise, underground and geological disruption) on shale gas exploitation in China [20]. The need for government to craft the community local content law through community stakeholder involvement is a key to the development of strategies to obtain an effective outcome for addressing the environmental impacts of oil and gas production [21]. These moderating factors among others are the major causes for concern in the issues of environmental impacts of oil and gas production [22]. However, it is important to note that many such interventions have not been fully embraced to properly address the environmental challenges of oil and gas production on the global scene.

Several factors are known to limit the effectiveness of interventions to address the environmental impacts of oil and gas exploitation. For example, the location of unexploited hydrocarbons presents a major setback to the strategies to offset the environmental impacts of oil and gas exploitation [23]. For example, protected areas are located on $3 - 15 trillion unexploited hydrocarbons reserves, posing significant challenges to the environment and its resources. The absence of routinely collected critical environmental data limits for places such as the North Sea (which is limited to 50 years), makes it difficult to effectively address the environmental impacts of oil and gas exploitation to achieve sustainable management of marine ecosystems [24]. [24] further argue that active and transparent communication and collaboration between stakeholders in the oil and gas industry is key to achieving effectiveness in mitigating the environmental impacts of the oil and gas industry because it results in barriers to data sharing-risk perception, working cultures, financial models and data ownership.

The case of oil and gas exploitation and its environmental impacts on communities nearby the Jubilee oil Fields in Ghana is no exception to the discourse as mitigation measures continue to face challenges. Some studies have identified sediment concentrations of organic and various metals (e.g. barium, copper, mercury, lead and Zinc) as major environmental pollutants of oil and gas production in the Jubilee Fields of Ghana [13]. Similarly, oil and gas exploitation in the Jubilee field has resulted in low fish catch, loss of jobs and livelihoods, increase in environmental degradation and pollution for the nearby communities [22]. Although oil and gas production in the Jubilee field has contributed immensely to the economic development of Ghana, the mining activities have also impacted on diverse ecosystems of mangrove swamps and freshwater swamp through contaminated streams and degradation of biodiversity in nearby com-

munities such as Ahanta West, Shama, Nema East/west, Jomoro, Elembelle and Sekondi-Takoradi [25]. In some other instances, the oil and gas production has created angling of about 500 m, which is a preventive tool adopted by these oil and gas producing companies to restrict the populace from accessing the mining area; a major recipe for conflict [26] [27] [28]. Meanwhile, a few mentions have been made in the extant literature on the effectiveness of measures adopted to mitigate the environmental impacts of oil and gas production in the Jubilee fields of Ghana.

This study, therefore, aims to evaluate the environmental effects of oil and gas exploration in the Western Region of Ghana. Specifically, the study will:

1a. assess the effectiveness of mitigation measures adopted to address environmental challenges associated with oil and gas industries in Ghana.

1b. explore whether the mitigation measures have impacted on compliance, cost of production, and community awareness in the industry.

2. Materials and Methods

The research applied a descriptive design to assess the perception of respondents on mitigation measures to address the environmental impacts of oil and gas exploitation. A multi-method embracing qualitative and quantitative approach was applied to allow for a better understanding of the issues being investigated [29]. By extension, a case study was applied to enable the researcher to comprehend complex social problems; it likewise enabled the researcher to hold an all-encompassing and significant thought for genuine occasions with regards to the effects of the exploitation of oil and gas on the people. The quantitative approach was useful in providing a statistical foundation to evaluate the environmental impacts of oil and gas production. The qualitative approach also provided some interpretation of the quantitative data.

The study coverage was mainly on the areas within the Jubilee Field where environmental impacts associated with oil and gas production are evident and efforts to mitigate the impacts and also cause some improvements are evident. Communities surrounding the oil and gas production area (Jubilee Oil Field) were specifically targeted. This comprised three communities; Shama, Newtown and Takoradi in the Western region of Ghana.

The target population defined to be a group of individuals with a common characteristic of interest to the research [30], consisted of the 547,368 people dwelling in the three communities-Takoradi, Shama and Newtown. The categorization of the respondents was 36% for Shama, 30% for Newtown and 34% for Takoradi. The communities were targeted for their closeness to the Jubilee Oil Fields. [31] formulae for establishing sample size was applied in determining the sample for the study.

$$S = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

$S =$ *Required Sample size*;

X = *Z value* (*e.g.* 1.96 *for* 95% *confidence level*);

N = *Population Size*;

P = *Population proportion* (*expressed as decimal*) (*assumed to be* 0.5 (50%));

d = *Degree of accuracy* (5%), *expressed as a proportion* (0.05); *It is margin of error*

Consequently, a sample of 150 respondents was assessed for the study.

The status of a respondent was established if the person had resided in the community for at least 5 years.

A combination of probability and non-probability sampling frames were used to access the respondents for the quantitative versions of the study. The cluster method-incorporating a 2-phase selection process was used to categorize the population, first into the 3 communities and then to households nearby the Jubilee Oil Field. A more convenient approach was the ultimate mode used to select the participants who responded to the questions. Both empirical and theoretical sources of data were explored for the study. Data collection tools were limited to the use of questionnaires and interview sessions. Questions have the character of being open-ended, 5-point Likert scale and also categorized into sections that explored the two (2) main objectives (1a) effectiveness of mitigation measures adopted to address environmental challenges associated with oil and gas industries in Ghana and (2) whether the mitigation measures have impacted on compliance, cost of production, and community awareness in the industry. Interview sessions also explored themes related to the objectives of the study.

Data were analyzed with the support of IBM Statistical Product and Service Solutions Statistic version 23. The descriptive statistics, Relative Importance Index (RII) and significance testing using a one-sample t-test module guided the analysis. The analysis is approached by the utilization of descriptive statistics (mean and standard deviation), relative importance index (RII) and one sample t-test with a test value of 3.4 as the statistical techniques to establish the measures. Relative Importance Index (RII) was calculated for each of the indicators and ranked accordingly. The RII derived summarized the importance of each indicator: Where, RII = weighting as assigned on Likert's scale by each respondent in a range from 1 to 5, where 1 = no impacts, 2 = negligible impact, 3 = marginal impact, 4 = moderate impact and 5 = major impact. The study used a 5-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. Results were presented in tables. Interview sessions were compiled into transcripts and later categorized into themes that directly reflected the patterns of the questions on the questionnaire. The transcripts were further used to provide further clarification of the statistics derived from the application of the various statistical modules.

3. Results and Discussions

The results and discussion present information on the effectiveness of mitigation

measures adopted to address environmental challenges associated with oil and gas industries in Ghana and on whether the applied mitigation measures have impacted on compliance, cost of production, and community awareness in the industry.

The educational level of respondents (Table 1) was fairly distributed; a majority (35%) with primary education, 23 percent with secondary education, 15 percent with university education and 27 percent with no education. The low levels of education for the majority of respondents did not affect the integrity of the research because such respondents were assisted by the research to digest and respond meaningfully to the questions posed. Participation in the study was not based on educational levels but, rather incorporated all standard of education. However, the high representative for the educated is a good sign due to the po-

Table 1. Demographic backgrounds of respondents.

Demographic Information		
	Frequency	**Percent**
Location		
Shama	54	36.0
New Town	45	30.0
Takoradi	51	34.0
Total	150	100.0
Educational level		
No education	40	26.7
Primary education	53	35.3
Secondary education	34	22.7
University	23	15.3
Total	150	100.0
Occupation		
Fisher	65	43.3
Farmer	15	10.0
Petty trader	21	14.0
Artisan worker	13	8.7
Fishmonger	25	16.7
Galamsay (mining)	11	7.3
Total	150	100.0
The monthly income you get from fishing-related activities		
Less than GH¢200.00	53	35.3
GH¢200.00 - 400.00	76	50.7
GH¢401.00 - 800.00	21	14.0
Total	150	100.0

Source: Field Study, 2018.

tential for people in the community to secure formal positions taking into cognisance the fact that the oil and fuel venture is restricted and expects measures to upgrade the level of training in these groups.

A majority (43%) of the respondents in the study were fishers and that printed a bleak image of their livelihoods due to the potential for the angling exercises to adversely impact on their livelihood activities. The other employment option in the community is people involved in ranching, unimportant dealership, craftsman labourers, angle mongers and galamsay (mining). This affirms an exploration of [26] and [28] that discovered angling associated with the oil and gas activities, to have a major impact on the livelihoods of the general populace nearby the Jubilee Oil Fields (Table 1).

On the income levels of respondents (Table 1), it was observed that 51 percent forming the majority, receive monthly incomes; 51% (majority) earning between GH¢ 200.00 ($34.65) and GH¢ 400.00 ($ 69.30), a few between GH¢ 401.00 (469.46) and GH¢ 800.00 ($ 138.58) monthly incomes from fishing related activities. A minimal number of respondents also received less than GH¢ 200.00 ($ 34.65) to nothing as monthly incomes. Generally, majority of the respondents earned incomes far lower than the national minimum wage of GH¢ 11.82 (US$ 2.05) [32]. The marginal incomes are indeed a clear recipe to potentially hype tensions and associated conflicts on issues related to improving livelihoods [22].

Measures Applied to curb the environmental impacts of Oil & Gas Industries in Ghana

An analysis of the measures taken to curb the environmental impacts of the Oil & Gas industries in Ghana is shown in Table 2. Mean scores approximated to any of these scales showed the level of agreement for each of the indicators, averagely. The rankings in descending order helped to arrange the indicators from the perspective of the respondents.

The highest-ranking (mean = 3.77, S.D 1.378, RII 75%) mitigation measure applied to address the issue of the environmental impacts of oil and gas industries is a conscious effort to package fuel and chemical storage such that, spillage is prevented. The least ranked mitigation measure is capacity building drives for

Table 2. Measures applied curb to the environmental impacts of oil & gas industries in Ghana.

	N	Mean	Std. Dev.	RII	Index Ranking
Fuel and chemical storage areas are enclosed to minimize the potential to impact soils in the event of spills.	150	3.77	1.378	75.3	1
Selected road systems are used as the best routes to reduce the impact and risk of accidents	150	3.51	1.048	70.1	2
Strict rules and regulations by the government to curb the impacts	150	2.81	1.517	56.3	3
Capacity Building for both oil industries and indigenes	150	2.75	1.305	55.1	4

Source: Field Study, 2018.

both people in the oil industries and indigenes. Key informants from the oil and gas production industry are of the view that the ranking manifests the chain of activity at the mining site. For example, effective packaging of oil and gas products to avoid spillage has a direct benefit on the production cost as it reduces waste and improves service quality and, therefore, given key attention in the entire production process. The second-ranked measure that has been taken to curb the environmental impacts of Oil & Gas industries related to the selected road systems; the variable is used as the best route to reduce impact and risk of accidents. Again, strict rules and regulations by the government to curb the impacts were the third measure been taken to curb the environmental impacts of oil and gas industries. The last was capacity building for both oil industries and indigenes with a mean score of 2.75 ± 1.305 and index of 55%, showing that there was minimal capacity building activity because rolling up capacity building plan is an additional cost since the producers are expected to also provide some forms of livelihood support opportunities for the populace nearby the Jubilee Oil Fields.

The last two measures were scaled as neutral; thus, respondents neither agreed nor disagreed with each of them. The test showed no significant results for measures taken to curb the environmental impacts of the Oil & Gas industries in Ghana. This confirms a study conducted by [10], which argues for compliance regimes to safeguard environmental compliance for oil and gas production activities. However, [13] contrasts the view of [10] by arguing that despite the improvement in compliance issues and legal regimes for many Sub-Saharan countries, there remains an increasing concern over the environmental impacts of oils and gas exploitation. This shows that many countries still need to improve issues of compliance for effective management of the adverse environmental impacts of activities associated with oil and gas production.

On the issue of significance testing (**Table 3**), the only variable that registered

Table 3. Measures that have been taken to curb the environmental impacts of the oil & gas industries in Ghana.

	Test Statistic	p-value	Hypothesis	Sig Level	Decision
Selected road systems are used as the best routes to reduce the impact and risk of accidents.	1.247	0.107	True mean ≤ 3.4	Not Significant	Accept
Fuel and chemical storage areas are enclosed to minimize the potential to impact soils in the event of spills	3.260	0.001	True mean ≤ 3.4	Significant	Reject
Capacity Building for both oil industries and indigenes	−6.068	1.000	True mean ≤ 3.4	Not Significant	Accept
Strict rules and regulations by the government to curb the impacts.	−4.737	1.000	True mean ≤ 3.4	Not Significant	Accept

Source: Field Study, 2018.

significant relationship (p = 0.001) for measures taken to curb the environmental impacts of oil and gas production was f*uel and chemical storage areas are enclosed to minimize the potential to impact soils in the event of spills.* Informants were of the view that barricading fuel and chemical storage areas to reduce the potential impacts of chemicals from the oil and gas production activity, has shown evidence of effectiveness, hence an important area to be given more attention in the event to address such impacts.

Challenges Associated with the application of Mitigation Measures to Address Environmental Challenges Associated with Oil And Gas Industries

This section assessed the effectiveness of measures that have been taken to curb the environmental impacts of the Oil & Gas industries in Ghana. The section utilized descriptive statistics (mean and standard deviation), relative importance index (RII) and one sample t-test with a test value of 3.4 as the statistical techniques to establish the measures. The study used a 5-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. Mean score approximated to any of these scales showed the level of agreement for each of the indicators, averagely. The rankings in descending order helped to arrange the perception of respondents on the challenges associated with the applied mitigation measures.

The results from Table 4 showed the effectiveness of mitigation measures applied to address environmental challenges associated with oil and gas industries. The most challenge to achieving effectiveness of the mitigation measures was the issue of lack of involvement (mean = 3.79 ± 1.007 and index of 75.5%). There is a high level of apathy in supporting mitigation measure as indicated by some key informants because the majority of the people do not witness any key results of the application of the measures in improving their livelihood opportunities. The least impacting challenge was the issue of lack of respect to the issue relating to the application of mitigation measures to address environmental challenges associated with oil and gas industries. Generally, the key informants agreed there is apathy to regulations and guidelines on oil and gas mining activities which are available but, the challenge is the process to ensure that the measures are applied to the activities of people involved in the production of oil and gas products in the Jubilee Oil Fields and nearby communities.

Significance test score identified that except for lack of respect, all the other

Table 4. Challenges associated with the application of mitigation measures to address environmental challenges associated with oil and gas industries.

	N	Mean	Std. Dev.	RII	Index Ranking
Lack of involvement	150	3.79	1.007	75.7	1
Lack of Motivation	150	3.77	1.362	75.5	2
Weak laws and regulations	150	3.65	1.118	72.9	3
Loss of Respect	150	3.43	1.378	68.7	4

Source: Field Study, 2018.

variables were significantly related to the challenges associated with the application of mitigation measures to address environmental challenges of oil and gas industries (at p-values of <0.001 - 0.004) (Table 5). There is, therefore, the need to address such challenges as they hold the direct link to the effectiveness of the applicable mitigation measures. The study confirms the outcome of several literature [11] [12] that suggested that issues of compliance, enactment and application of laws and regulations as key issues mitigating the effective implementation of measures to address oil and gas production.

4. Conclusions

The study which investigated the challenges associated with the implementation of mitigation measures to address the impact of oil and gas production covered a population of 547, 368 of which 400 were sampled; 34%—Shama, 30%—New Town and 36% from Takoradi communities in the Western Region of Ghana.

Major decisions in mitigating oil and gas impacts on the environment are rated as; first for conscious effort to package fuel and other chemicals in safe storages, followed by the use of best road systems to reduce the risk of accidents, then application of strict rules and regulations to curb impacts and lastly capacity building for participants in the oil and gas production industry. It is rather recommended that for effectiveness in the management of the environmental impacts of the oil and gas production industry, stakeholders in the section should emphasize more on enclosing fuel and chemical storage areas to reduce the potential impacts of soils in the events of spills as the approach would have a significant impact of and product better outcome.

While significant measures have been adopted to mitigate the effects of oil and gas exploration, there remain challenges with effectiveness as a result of issues of lack of community involvement, lack of motivation, weak laws and regulations and loss of respect. local participation within the management of the water bodies and the environment as a whole was very low. Indigenous knowledge was found to be valued and respected by all segments of the society with the community having powerful structures to ensure smooth compliance aside few controversies that existed. For effectiveness in reducing the challenges to mitigate the environmental impacts of the oil and gas production activity, policymakers, as well as the practitioners in the oil production industry, are advised to motivate

Table 5. Challenges associated with the application of mitigation measures to address environmental challenges associated with oil and gas industries.

	Test Statistic	p-value	Hypothesis	Sig. Level	Decision
Loss of Respect	0.296	0.384	True mean ≤ 3.4	Not Significant	Accept
Lack of Motivation	3.358	0.000	True mean ≤ 3.4	Significant	Reject
Lack of involvement	4.702	0.000	True mean ≤ 3.4	Significant	Reject
Weak laws and regulations	2.702	0.004	True mean ≤ 3.4	Significant	Reject

Source: Field Study, 2018.

people into accepting and adhering to environmental policy on reducing the adverse impacts of oil and gas production. More so, efforts should be channelled into reducing apathy among the stakeholders as well as energising the enforcement of the various laws and regulations guiding the oil and gas production industry, especially as it related to the issue of mitigating the environmental impacts of the oil and gas production industry.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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