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A REVIEW OF ENVIRONMENTAL MANAGEMENT AND CONTROL DURING PETROLEUM EXPLORATION

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ABSTRACT

During oil and gas exploration, sustainability is critical to the industry, due to the generation of wastes, possible environmental contamination and release of gaseous emissions such as carbon dioxide. Diverse wastes generated during the process include drilling muds, produced water, drill cuttings and other constituents that can impact the environment and the communities around such operations. Nevertheless,

Introduction

Globally, deepwater wells have increased significantly (Dou et al., 2022). The petroleum industry is developing rapidly in intelligent exploration and development to reduce risks to the environment at lower costs (Kuang et al., 2021). This is because of the potential environmental incidents that can occur during the exploration and development processes, which are sometimes linked to carbon emissions, and other discharges to the environment. The need to adhere to stringent regulations and manage agitations from local and international bodies is now a priority in the oil and gas sector (Albeldawi, 2023). Exploration and development wells are used to discover commercial accumulations of hydrocarbons, to develop them (Kaiser, 2021). An increase in offshore oil and gas developments requires adequate environmental protection of marine resources and evaluation of environmental management performance (Liu et al., (2020). Oftentimes, when offshore drilling incidents occur, the marine environment is impacted (Dong & Guan, 2020). The negative outcomes from resource extraction can be minimised by local content and local participation laws

advancements in oil and gas drilling techniques minimise environmental impacts, thus driving sustainability and strategies that can effectively reduce waste generation, pollution and gaseous emissions. This study investigates environmental management and control during petroleum exploration. The study adopts a qualitative approach through review of literatures, to study the issues during petroleum exploration. The major findings reveal the rapid improvement companies are taking to account for their activities that can interfere with the environment. In conclusion, whilst oil and gas revenues continue to foster social and developmental opportunities, hazards and controls must be established to effectively structure environmental compliance with best practices.

Keywords: Environmental control, Exploration, Oil and Gas, Sustainability, Waste Management.

and policies that promote linkages between the oil sector and the management of the environment (Ablo & Otchere-Darko, 2022). Due to the importance of oil and gas activities in the global economy, big data technologies are adapting systems to enhance production opportunities and data analysis to enable petroleum industries to account for the greenhouse gases they emit (Li et al., 2023).

Seismic Operations During Exploration

Exploration activities are capable of generating several environmental impacts (Chinenyeze et al., 2017). A seismic survey is a field operation carried out during exploration, which is mainly short-term, but can cause disturbances through ground vibrations and noise (Singh et al., 2007). Hence, novel seismic exploration methods are adapted to expanding oil and gas developments (Qu, 2005). Seismic exploration surveys conducted offshore can produce high-intensity and low-frequency impulsive sound intervals, ranging between 10 and 300 Hz, which may be disruptive to some fishes and vertebrates (Carroll et al., 2017). A study by McCauley et al. (2000) showed that captive fish exposed to short-range air gun signals were seen to have some damaged hearing structures (McCauley et al., 2000). During seismic operations in the Otway Basin in Australia, avoidance of environmentally sensitive areas and vegetation clearing was achieved by the innovative use of the Speculand 3D Transition Zone Seismic Survey (Aouad et al., 2012). Despite novel applications to

minimise environmental impacts imposed by seismic surveys, environmental and cultural restrictions are increasingly focusing attention on exploration activities for minerals (Driml et al., 2001).

Extensive use of robust, low-frequency air-gun pulses for seismic seabed exploration has stimulated anxiety about possible negative effects on marine wildlife (Madsena et. al., 2006). Characteristics such as the depth, temperature, salinity, surface and bottom conditions, influence the speed at which sound travels, which is estimated to be four times faster in water than in air (Brahic, 2008). Fishes are capable of detecting sounds at low-frequency such as <500 Hz (Popper et al., 2014). As different locations are opening up for oil and gas activities, wildlife populations in such environments can be impacted. A decline in disturbance of wildlife such as polar bears in the Coastal Plain of the Arctic National Wildlife Refuge in Alaska, can succeed through effective planning and scheduling of survey activities (Wilson & Durner, 2021). Effective environmental protection and management during seismic operations is feasible through the integration of seismic acquisition contractors and operators, working jointly with the regulatory authorities to achieve compliance (Vaughan, 2007). Close collaboration enables the delineation of those areas and periods that are most important to protect (Sivle et al., 2021). For onshore seismic surveys, a strict environmental management plan can drastically reduce the destruction of flora and fauna as well as vegetation (Long & Long, 1992). The magnitude of such impact depends greatly on specific environmental conditions, and the application of innovative approaches to maximize both safety and environmental mitigation (Engelhardt et al., 1994).

Geophysical Investigations

Dynamite, which was the most preferred seismic method of operations in the past, has been replaced by more environmentally friendly methods (Morton, 2022). Exploration and development activities are expected to increase as a consequence of recent 3-D seismic investigations. It has been projected that in places such as Iraq's Kurdistan region, oil and gas development and production may perhaps increase significantly (Amer, 2021). Since the discovery of oil and gas in Nigeria, exploration of crude oil has increased revenue, though with some environmental damages (Bello & Nwaeke, 2023). The United Kingdom has the potential for shale gas exploration in different parts, which is capable of offsetting energy costs for decades, with an effective environmental management system and regulatory scheme (Ochieng et al., 2015).

For large area coverage, geophysical methods are executed as a reconnaissance procedure before conducting a geotechnical investigation, as a precautionary measure to limit environmental consequences such as flooding, and groundwater contamination (Ibitoye, 2023). Petroleum exploration technologies based on the main migration pathway and nano-hydrocarbon can minimise risks and have been effective in the development of the Chinese petroleum industry (Liu et al., 2022).

Studies on the environmental and social impacts of the oil and gas industry in tropical latitudes have recorded cases of contamination of flora, fauna, soils and water, alongside health problems and adverse effects on local livelihoods (Bebbingto & Bury, 2013; Orta-Martínez et al., 2018). As governments are implementing more stringent measures to cut down emissions, it is speculated that some key policies will focus directly on oil and gas production (Plume, 1995). Current climate emergencies worldwide are key drivers in setting ambitious targets to reduce carbon emissions, especially in the energy sector (Caruso et al., 2023). Most oil and gas companies now have mitigation and monitoring guidelines, especially for their offshore petroleum exploration activities (Prideaux & Prideaux, 2016). Mitigating immediate impacts is critical, however monitoring for short-term as well as long-term effects and impacts is a necessity (Nowacek et al., 2013). Early identification of regulatory requirements will enable the design of an environmental impact assessment and monitoring programme that provides adequate environmental control and management of discharges (Wattana et al., 2022).

Drilling and Well Completion Operations

Changing drilling fluid properties is expected to influence drilling performance and the amount of cuttings suspended in the annulus (Carter, et al., 2023). However, oil and gas well drilling, and completion still experience severe challenges, thus limiting their capacity to drill deep and ultra-deep wells safely, quickly and optimally (Wang et al., 2022). Advanced technologies such as artificial intelligence have become inevitable in the petroleum industry while digital twins and physics-guided neural networks are projected to enhance drilling and completion engineering (Li et. al., 2022a). Petroleum companies such as China National Offshore Oil Corporation (CNOOC) are expanding their frontiers to adapt independent technological innovation, to quicken the pace of Deepsea oil and gas, and continue to research key core technologies for oil and gas reserves and production increase (Li et al., 2022b). Further, vision analytics is being used to improve health and safety cases and increase

efficiency (Chatar et al., 2022). In the United Kingdom, safety in the offshore oil and gas industry is now enforced through a system of goal setting whereby the operator sets safety standards and demonstrates how these are achieved during well examination (King & Dobson, 1998). The regulations of the United Kingdom's offshore oil and gas industry are experiencing continuous improvements to boost performance standards for drilling and well operations (Powell et al., 1995). British Petroleum Amoco developed a drilling environmental awareness program where environmental guidelines were incorporated into a strategy to improve the compliance of drilling engineers across their organisation (Cranmer, 2000). This facilitated collaborative learning behaviour and performance in their drilling operations (Dewhirst et al., 2000). Hydrocarbon Engineering Services (HES) Oil and Gas Solutions in Columbia designed an integral waste management system to improve waste management at rig sites (Pedraza & Mario, 2007). A waste management plan developed with the relevant regulatory authority, for the deepwater horizon, can effectively provide lasting solutions to potential short-term and long-term environmental impacts (Sweeten, 2012). This will require visits to operating locations and disposal facilities to achieve a significant volume of hazardous waste reduction (Haynes & Redweik, 1992). The Office of Solid Waste (OSW) of the U.S. Environmental Protection Agency (EPA) envisage collaborative efforts of the petroleum industries, regulatory bodies and third-party contractors to achieve best practices in the management of exploration and production wastes (Derkics et al., 1992). Regulating and implementing environmental controls in the petroleum industry are essential for curtailing the potential environmental impacts and protecting human health and the environment (Jafarinejad, 2017).

Hydrocarbon Prospecting

The purpose of hydrocarbon exploration is to detect and define structural and stratigraphic traps appropriate to cost-effectively exploit deposits and to delineate the extent of discoveries in field appraisals and development (Dobrin, 1976). Thus, different approaches are deployed such as spectral decomposition techniques to assess the hydrocarbon potential of the reservoir (Ugbor & Onyeabor, 2023). Enhanced exploration success can be attained through an improved approach/technique by incorporating risk analysis (Ugbor et al., 2023). Adeoti et al. (2014) demonstrated the effectiveness of the 3-D static modelling technique as a tool for improved investigation of the spatial distribution of discrete and continuous reservoir properties and

developed a framework for future prediction of reservoir performance (Adeoti et al., 2014). While Dagogo et al. (2016), discovered that the integration of well and time-lapse seismic (4-D) data in reservoir studies can remarkably improve information on the reservoir's economic potential, and enhance the hydrocarbon recovery factor (Dagogo et al., 2016).

The oil industry is constantly operating on the edge to explore and discover new reserves (Leil, 2023). Certain exploration activities adversely impact the host communities and their sources of livelihood (Osanebi & Madu, 2019). Thus, a balance between exploration and production of hydrocarbon and environmental integrity has become a universal concern due to the realities of global warming and marine pollution which implies safer operations (Adebayo & Tawabini, 2012).

Explosives in the Petroleum Industry

In the petroleum industry, only authorised explosives are used for good perforation or seismic exploration (Queensland Government, 2021). Advancements in geophysical survey techniques, such as magnetic and gravity methods, to seismic methods, have made the commercial exploration of crude oil possible (Adeola et al., 2022). Geology-engineering integration including well trajectory optimization, high-efficiency drilling, completion and reservoir reformation technologies has enabled growth during the exploration and development of oil fields (Ma, et al., 2022). Zhang et al. (2023), propose an intelligent safe operation and maintenance technology system to control operations and maintenance risks (Zhang et al., 2023).

Environmental Management and Control

Exploration, extraction, development, and production activities in petroleum industries generate enormous volumes of waste materials (Asim et al., 2021). Inadequate management of hazardous waste can cause great threats to the environment, plants animals and human life (Nwankwo et al., 2020). Wang et al. (2023) suggest reinforcing the life-cycle management of hazardous waste from oil and gas operations by creating a hazardous waste information control platform to realize the whole-process tracking management (Wang et al., 2023). The waste management hierarchy is a viable protocol for environmental protection and sustainable development within the oil and gas drilling and production industry (Dahab, 2019). Further, there are several levels of environmental regulations set by different countries to provide conditions for effective environmental management and technology during operations (Tai

& Lee, 2008). In Nigeria, the Petroleum Industry Act (PIA) makes provisions for environmental regulation of oil and gas operations. While the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) technically and commercially regulates the upstream operations (Chigonu et al., 2022). In Uganda, the development of the oil and gas sector has led to significant investments, and it's still attracting and sustaining high levels of desired investments, goods and services (MEMD, 2008). There is increasing recognition and regulatory force to implement sustainability measures in Europe (De Bristo et al., 2008). As the world's economy continues to depend on oil and gas resources, sustainable supply chain management practices are required to mitigate environmental impacts and expand economic and social developments (Ahmad et al., 2017). Opportunities for developing a long-term strategy for public investment in education, health, transport, and power generation are some of the high expectations from Papua New Guinea's petroleum development (Parsons & Vincent, 1991). Some benefits associated with oil and gas exploration in Ghana are traceable to the development of social amenities and appreciation of income levels for people living near oil and gas development sites (Arthur & Chantel, 2020).

Discussion of Finding

Oil and gas activities are at the centre of interest due to their global relevance. The environment where these activities are conducted also have natural habitats that are beneficial to the communities where they operate. Though there has been improvements in exploration and development activities, safety techniques and policies, the regulatory agencies are constantly reviewing conditions for the petroleum industry operations. This is a constant drive to improve their structures, environmental awareness programmes, and safety techniques, thus minimising risks in the process. On the other hand, the oil and gas companies recognise the importance of having a framework that promotes sustainability and safety standards during their offshore and onshore operations. Learnings from British Petroleum Amoco and HES Oil and Gas Solutions are typical examples of efforts made by the oil and gas industries.

Conclusion

Mechanisms for meeting environmental management requirements and regulatory expectations are of importance to the oil and gas sectors. Consistent innovations in exploration and development is focused on reducing environmental and socioeconomic risks which may occur due to possible

discharges. As there is a tendency for expansion of oil and gas developments, more control measures must be established to effectively structure environmental compliance with best practice.

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