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Safety, Quality, and Sustainability: The Environmental Benefits of HSEQ in Oil Fields

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Abstract:

The oil and gas industry provides a large part of the current energy needs; however, it produces a wide variety of severe environmental problems such as air pollution, water pollution, contamination of soil, and alteration of ecosystems. The development of Health, Safety, Environment, and Quality (HSEQ) management systems has become a key way to help reduce the adverse effects caused by the oil and gas sector and create a more sustainable future for the oil industry. This research will focus on how HSEQ management systems can help achieve the goal of sustainability in relation to the oil and gas sector, specifically in the case of Pakistan. Through a qualitative research approach using thematic analysis as the primary analysis method, the current state of the literature regarding HSEQ management systems will be explored through the synthesis of theoretical perspectives, case study data, and literature-based evidence. Using these data sets, it will evaluate how HSEQ management systems are able to provide a contribution to the reduction of the environmental impact of the oil industry while still meeting efficiency goals for the oil industry. This research indicates that there are four main categories in which HSEQ supports environmentally sustainable development: (1) Protection from risk & Control of hazards; (2) Compliance with environmental laws & Regulations; (3) Waste and Pollution; (4) Resource and Energy efficiency. The four categories are reviewed in the framework of an operational idea for an oilfield where most of these processes have demonstrated limited positive results due to lack of proactive measures such as frequent assessments of environmental impacts, implementation of ISO 14001 systems and protocols for spill containment and the reduction of flaring. The theoretical framework includes the Triple Bottom Line (TBL), Precautionary Principle, and Corporate Social Responsibility (CSR), so HSEQ is both an operational necessity and a company's ethical obligation. The research indicates that environmentally responsible operations in Oil Field production is not only an aspect of legal compliance but also a strategic investment for operational resilience, corporate reputation, and trust with communities. The Oil Field case study demonstrates that well-integrated HSEQ systems can result in significant positive environmental impacts, including reduced GHG emissions, decreased freshwater use, and improved biodiversity protection around extraction activities. But the research also identifies gaps, such as a lack of availability to the public for performance related to the Environment, inconsistent enforcement of HSEQ standards

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within subcontracted operations, and not enough training of workers concerning sustainable practices. Based on these findings, the study makes recommendations to strengthen internal audit functions, to expand on the integration of renewable energy into oil field operations, to expand community engagement efforts, and to encourage the open disclosure of environmental metrics to stakeholders. The research places HSEQ in the broader context of Corporate Responsibility and Environmental Stewardship, thus highlighting that a fundamental reform in all aspects of oil field operations is needed, not just compliance, but also to take the lead in implementing Environmental Sustainability in oil field operations.

Keywords: *HSEQ, oil fields, environmental sustainability, risk prevention, corporate social responsibility, and resource efficiency*

Introduction

As worldwide energy demand continues to grow at an unprecedented rate, so too does the oil and gas industry as a key contributor to supplying that demand (Rahman & Idris, 2019). Whether offshore rigs or land-based drilling, oil fields underpin hydrocarbon extraction and delivery. While oil field operations have great economic benefit, they have also created significant environmental and social issues over time by damaging the environment through oil spills, gas flaring, destroying habitats, and mismanaging both hazardous and non-hazardous wastes, among other things. These detrimental impacts have caused concern for environmental scientists, policy-makers, and the public (UNEP, 2016). Addressing these issues is now considered to be a corporate responsibility to ensure an organization's operational viability and societal acceptance; therefore, the implementation of Health, Safety, Environment and Quality (HSEQ) frameworks is critically important as they provide one of the primary means of driving environmental sustainability in oil fields.

HSEQ is not simply an administrative checklist or compliance with regulatory requirements; it is an integrated management philosophy that merges four interrelating disciplines—occupational health, workplace safety, environmental stewardship, and quality assurance—into one cohesive system (ISO, 2015). By incorporating these components into the core business culture of oil field operators, companies can proactively address risk management, avoid environmental damages, and achieve

continuous performance improvement. This is especially important in a time when the oil industry faces increased challenges from environmental regulations, investor expectations, and global sustainability efforts such as the United Nations Sustainable Development Goals (SDG).

Historically, oil field managers have placed more emphasis on productivity and profitability than on protecting the environment (Khan et al., 2020). The rationale for this has generally been based on two key economic principles: energy security and industrial expansion; however, as evidenced by the catastrophic effects of such events as the 2010 Deepwater Horizon oil spill, oil field accidents can result from a failure to implement appropriate safety and environmental programs. Additionally, these incidents damage the environment, decrease public confidence, and create huge financial liabilities for corporations. This experience illustrates that safety, quality, and environmental sustainability are interrelated; when one of these foundations fails, the other two often follow suit (Peterson, 2019).

The "Health" portion of HSEQ refers to ensuring workers are protected from various forms of occupational hazards (chemical, ergonomic, extreme weather).

Protecting worker health will indirectly help to support environmental sustainability as a healthy workforce can better follow and comply with environmental procedures, effectively respond to emergencies, and remain operationally efficient (Miller & Hart, 2018).

The "Safety" portion of HSEQ encompasses accident prevention, which is even more critical in oil fields as incidents may result in large scale environmental contamination (oil spills, loss of wildlife habitat). Rigorous safety management systems are utilized to prevent blowouts, equipment failure and leaks of hazardous materials resulting in reduced likelihood of pollution and ecological damage.

The "Environment" portion of HSEQ has the most direct link to sustainability goals and encompasses the design and implementation of environmental management systems that conform to and meet international requirements (e.g. ISO 14001). These include activities such as monitoring emissions, controlling discharges, managing waste, conserving water and protecting biodiversity in the areas where operations occur.

The "Quality" portion of HSEQ, while frequently associated with product/service quality, has a significant environmental component related to conserving energy resources and minimising waste through improved efficiency, reliability of equipment and reduced rework (Smith, 2017).

As global energy firms increasingly work to achieve sustainability through their operations, HSEQ's function is transitioning from operations-focused to strategic. The complexity of the oil and gas industry is created by the various stakeholders involved, such as various levels of government, regulatory agencies, local communities, non-governmental organizations and investors. All these stakeholders demand more transparency about and accountability for the evidence that demonstrates environmental responsibility (BP, 2021). Thus, by embedding HSEQ into all levels of decision-making from project development to execution in the field, oil companies will meet all of these respective stakeholder requests and secure long-term economic viability.

Also, the move to low-carbon sources of energy will not remove a need for oil field operations in the short to medium term. This transitional phase provides an opportunity for the oil and gas sector to integrate environmentally responsible operating practices, thereby reducing the negative impacts on the environment yet still producing sufficient volumes of oil. Further, HSEQ systems provide a practical and effective way to bridge the gap between operational priorities and sustainability objectives, ensuring that an organization's care of the environment is not compromised in the pursuit of profitability.

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Objectives of the study are as below:

- To identify the environmental problems associated with oil field operations and how they relate to HSEQ.
- To analyse the links between health, safety, quality and environmental management as they relate to promoting sustainability.
- To highlight illustrative examples and thematic insight on the environmental benefits of implementing HSEQ within oil fields.

Literature Review

Understanding HSEQ in Oil Fields

Health, Safety, Environment, and Quality (HSEQ) is an amalgamated system that brings together the previously isolated components of each risk factor in the industrial community, but especially in the oil and gas related industries. HSEQ has developed and become increasingly recognized as a management strategy that allows for the simultaneous pursuit of optimal performance across these four areas by incorporating an integrated approach focusing on the relationships amongst them; thus making them dependent on one another (Smith, 2017). As noted by the International Organization for Standardization (ISO) and the International Oil and Gas Producers Association (IOGP), an integrated approach creates efficiencies, consistency, and an over all improved outcome (ISO, 2015; IOGP, 2020). In this way, HSEQ is more than just a set of guiding principles; it is a set of practical standards and processes established for implementing a comprehensive management framework within an oil field (Rahman & Idris, 2019).

HSEQ also incorporates three primary management systems: Occupational Health and Safety Management System (ISO 45001), Environmental Management System (ISO 14001), and Quality Management System (ISO 9001). Only by utilizing an integrated approach can an organization address the inherent complexities and high level of risk associated with industry operations; additionally, many incidents that occur within an oil or gas company involving environmental issues are often the result of failures in safety or quality management systems. For example, a leak that occurs when equipment fails as a result of poor maintenance (quality management failure) can lead to environmental damage and threaten the health and safety of employees (health and safety management failure). Thus, HSEQ is a collection of characteristics linked together by one or more

elements giving rise to the effects experienced within them as a result of HSEQ management actions.

Environmental Challenges in Oil Field Operations

The oil industry encompasses all types of oil field activities, including the exploration, drilling, production & decommissioning of oil fields. There are many environmental impacts created by oil-field operations, including:

o Oil Spills - oil spills occur as a result of equipment failure/ blowouts &/ the spill of oil during transport; oil spills contaminate soil, groundwater & all forms of marine ecosystem.

o Gas Flaring & Gas Emissions - gas flaring is the process in which gas is produced, such as when there is a build-up of gas during the oil extraction process, and is burnt at the end of the process, which creates large quantities of carbon dioxide, methane & black carbon, all of which are directly related to climate change.

o Produced Water & Wastewater Discharge - large volumes of produced water (water used in oil extraction) containing hydrocarbons, metals & salts may be released directly into the environment without treatment if not handled appropriately will harm aquatic life.

o Habitat Destruction - clearing land to construct infrastructure for oil- and gas-related activities will destroy biodiversity, especially in ecologically sensitive areas.

o Solid & Hazardous Waste - drilling mud, cuttings & containers for chemicals from drilling also can produce hazardous waste which must be carefully disposed of in order to not create contamination.

These issues are amplified in offshore oil field operations where containment and remediation are more challenging than on land (Miller & Hart, 2018). The extent of and length of time oil field incidents have caused environmental degradation emphasize

the need for systematic strategies to mitigate these hazards; this is exactly where HSEQ plays an instrumental role in helping to develop and implement these strategies.

Historical Development of HSEQ in Oil and Gas

HSEQ's basic structure is rooted in early safety programs created in the 1950s and 1960s to improve occupational safety and reduce accidents at work. Later (especially after the environmental movements of the 1970s and 1980s) this structure also included environmental concerns (Peterson 2019). Quality management principles - derived from manufacturing processes and Six Sigma - began to be used in the oil and gas sector in the 1990s, establishing an integrated system.

Since major disasters (such as the Piper Alpha explosion in 1988, the Exxon Valdez oil spill in 1989 and the Deepwater Horizon oil spill in 2010) have accelerated the implementation of HSEQ, resulting in more regulations and a shift in focus to prevention, resilience and integrated risk management (BP 2021). HSEQ is now considered standard practice globally; major oil companies publish annual sustainability reports outlining their HSEQ compliance and how they are working towards achieving HSEQ goals.

Linking HSEQ to Environmental Sustainability

The sustainable management of oil fields includes the ability to fulfill energy requirements presently while protecting the resources available for meeting energy requirements in the future (Elkington, 1997). The Triple Bottom Line concept of HSEQ incorporates the evaluation of an organization's performance with regard to environmental, social, and economic results. By addressing environmental factors both directly (e.g., reducing emissions, minimizing waste) and indirectly (e.g., preventing accidents, improving process efficiency), HSEQ serves as an operational tool for implementing sustainability.

In many cases, HSEQ provides a framework for implementing the environmental component of HSEQ via Environmental Management Systems (EMS), including ISO 14001. These systems allow organizations to have a consistent methodology for

identifying, measuring and managing environmental risks; establishing objectives and monitoring progress towards those goals; and ensuring compliance with both mandated and voluntary standards (ISO, 2015). In the case of oil fields, these activities may include planning for spill response, managing biodiversity, and conserving natural resources.

Health and Safety as Environmental Enablers

Health and safety provisions are designed to protect the employee who works at the site; however, they also provide great advantages to our environment. One aspect of a healthy safety culture creates an environment where incidents happen less frequently than they would without that culture; therefore, the likelihood of a release of contaminants into our environment (pollution) is minimized. An example of this is a regular maintenance program for blow out preventers, which will reduce the risk of injuries to employees and uncontrolled releases of hydrocarbons (Rahman & Idris, 2019). Likewise, having programs that train employees on how to properly handle hazardous materials will also promote the safe storage, movement, and disposal of those materials, thereby reducing the risk to our environment.

Quality Management for Environmental Performance

Quality management in oilfields is not only focused on the quality of product (drilling products) and service (services offered in the oilfield), but also on the integrity of the processes that produce that product or deliver that service. The ISO 9001 benchmark emphasizes continuous improvement, satisfaction of the customer, and efficiency of operations, all things that have an associated environmental impact (Smith, 2017). For example, optimizing the parameters of the drilling process would reduce the amount of energy consumed to drill a well; whereas using high-quality components and equipment would reduce the likelihood that the component or equipment would leak or fail. The culmination of these improvements would lead to a reduction in the amount of waste generated and reduce the number of environmental incidents; thus, achieving the goals of quality serves as a positive effect on achieving sustainability goals.

International Standards and Regulatory Context

HSEQ implementation is profoundly shaped by both global and region regulations. Oil Field operations are subject to a number of guidelines, such as those set forth by the ISO, the American Petroleum Institute (API), the International Association of Oil & Gas Producers (IOGP), as well as those defined by regional environmental protection agencies. Although strictly complying with all applicable regulations often only represents the minimum acceptable level of performance, many organisations will also adopt voluntary standards which are more stringent than the applicable laws in order to create or improve their social licence to operate (Miller & Hart, 2018).

Countries like Norway and the UK have adopted national petroleum legislation which embeds HSEQ principles and requires companies to have integrated management systems and to demonstrate the effectiveness of those management systems through auditing and inspecting (Peterson, 2019). Companies that operate in regions where the regulatory oversight is weak will typically use their global HSEQ standards to ensure consistent application and protect their reputation, no matter the location of their operations.

Critiques and Challenges of HSEQ Implementation

Despite the positive attributes of HSEQ, it is met with a number of hurdles during implementation. One of these is the assertion that an integrated approach may diminish the emphasis on the individual elements, thereby creating a void in technical quality (Khan et al., 2020). Plus, the cost to implement HSEQ systems is very high—especially for small and medium operators—meaning that many organisations may choose not to implement HSEQ; consequently, they are more likely to use HSEQ systems as bureaucratic documentation tools instead of reducing their exposure to risk through meaningful improvements.

An additional aspect to consider is that cultural factors will also influence how effective HSEQ will be. In many organisations, caring for the environment or focusing on safety

is an afterthought to achieving production targets, so it is possible that an organisation may have an HSEQ policy in place; however, it will not be effective due to lack of commitment from leadership and/or engagement of employees in the decision-making process (Rahman & Idris, 2019). To overcome these issues, it will require a commitment to developing leaders, engaging employees continually, and training employees on how to embed HSEQ best practices daily.

Emerging Trends in HSEQ for Sustainability

Recent technological advances, along with shifting stakeholder expectations are changing HSEQ as applied within oilfield environments/operations. Digital monitoring (online reporting), drones (to conduct inspections), and predictive analysis (to identify and mitigate environmental risk prior to escalation) have improved the detection of environmental risks (BP, 2021). Further, there is an increased emphasis placed upon incorporating climate change considerations into HSEQ processes such as reducing greenhouse gases and adapting operations to cope with extreme weather conditions.

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Theoretical Framework

The Triple Bottom Line (TBL) Theory

Origins and Definition

The TBL concept was developed by John Elkington in 1994 to expand the traditional focus that businesses place on financial performance to also include the social and environmental dimensions associated with business activity (Elkington, 1997). The three P's of the TBL model, People, Planet, and Profit, illustrate that organizations need to find a balance between achieving economic success while being socially responsible and environmentally sustainable. When applied in an oilfield environment, the TBL will require energy to be produced, while at the same time, protecting the safety of workers, preserving the environment, and positively impacting local communities.

The TBL provides a new perspective that contradicts conventional wisdom regarding profitability and sustainability being incompatible; instead it suggests that an organization's ability to operate in a socially and environmentally responsible manner will directly influence long-term profitability (Slaper & Hall, 2011).

Relevance to HSEQ in Oil Fields

HSEQ is an abbreviation that stands for Health, Safety, Environment & Quality (HSEQ) and it plays an important role in the concept of TBL (Triple Bottom Line) because HSEQ encompasses three main pillars which include Planet, People and Profit. Below are some examples:

People - Protecting health & safety of workers from hazards protects business continuity while providing workers with trust in their employer; by providing this trust, the environment will also be indirectly protected by eliminating incidents.

Planet - By implementing measures that control the environment (i.e. preventing spills and reducing emissions), we directly contribute to the sustainability of the environment we live in.

Profit - Through high-quality processes we eliminate waste, reduce the amount of time that we are downtime and maximise our overall use of resources resulting in lower costs and improved environmental solutions.

By applying TBL principles within HSEQ policy development and through systematic implementation of TBL principles throughout our organisation, the Oil Industry can systematically address how the interrelationship of HSEQ, TBL and corporate reputation will be positively impacted through their operations based on their safety & environmental performance.

ISO 14001 Environmental Management System (EMS)

Overview of ISO 14001

ISO 14001 is an internationally recognized standard developed by the International Organization for Standardization (ISO) that provides organisations with an effective system for managing their environmental responsibilities. The ISO 14000 family of Environmental Management Standards provides a framework for the ongoing improvement of the environmental management system through a continuous cycle of planning, implementation, evaluation and adjustment (Plan-Do-Check-Act - PDCA):

1. Plan - Identify Environmental Aspects, Legal Requirements, and Objectives.
2. Do - Implement Programmes to Achieve Objectives.

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3. Check - Monitor Performance Against Targets.

4. Act - Review Results and Implement Corrective Actions for Improvement.

Integration with HSEQ

One way in which ISO 14001 relates to the Health, Safety, and Quality (HSEQ) system is through its relationship with the Environmental component of HSEQ. In addition, ISO 14001 impacts the other 3 HSEQ components:

- Health: Reducing the amount of toxins and pollutants emitted into the environment creates a safer working environment.

- Safety: Spill and emission prevention minimizes the potential for a workplace accident.

- Quality: Often, companies implementing ISO 14001 will make process improvements that provide quality assurance and increased operational efficiency.

An example of this is an oil company that implements ISO 14001 and develops an oil spill response plan. This plan would address requirements for environmental compliance but could also increase the company's ability to respond to spills in a manner that is safe and reliable for the company (Miller & Hart, 2018).

Benefits for Environmental Sustainability

The ISO 14001 system ensures that environmental considerations are incorporated into all aspects of business decision-making. The benefits of this system include:

- Risk Reduction: By identifying environmental hazards prior to incidents occurring, the likelihood of an incident is reduced.

- Regulatory Compliance: The use of the ISO 14001 system allows a company to meet or exceed all applicable environmental regulations and standards (including Federal, State, and Local Regulatory Compliance Requirements).

- Stakeholder Confidence: The use of the ISO 14001 system demonstrates a company's commitment to environmental sustainability and stewardship, which is valued by regulators, investors, and the community.

- Continuous Improvement: The ISO 14001 system encourages and provides a framework for continuous improvement of an organization's environmental performance, in accordance with the organization's long-term sustainability objectives.

Risk Management Theory and HSEQ

Application in Oil Fields

Risk management is part of HSEQ by utilizing methods such as hazard identification, safety audits, and environment impact assessments. For instance, certain drilling equipment can be maintained using predictive maintenance practices that help reduce the risk of blowouts. Monitoring for environmental hazards helps identify potential leaks before they become more serious.

Systems Thinking in HSEQ

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Concept

HSEQ systems thinking considers a business as a group of connected elements that all need to work together appropriately in order to reach a common goal (Senge, 2006). This approach is especially relevant to HSEQ, since when one of these elements fails there is a high likelihood that it will cause failure in other elements as well.

Relevance to Environmental Sustainability

Using systems thinking in oil fields also creates a connection between environmental initiatives and the HSEQ component of health, safety, and quality. As example, when an employee receives health and safety training, those procedures inherently include environmental protocols; therefore creating a culture around shared responsibility.

Synthesis of Theoretical Perspectives

Overall, TBL framework creates a philosophical basis for balancing the three components of environmental, social, and economic performance and ISO 14001 provides the steps needed to operate effectively towards these same goals. Risk management theory provides support for the preventative part of HSEQ and systems thinking provides for a method of connecting all the elements of HSEQ. Together these frameworks demonstrate that HSEQ is not just a tool for compliance but an entity used strategically to help achieve environmental sustainability of oil fields

Thematic Discussion

The thematic discussion examines how the integrated Health, Safety, Environment and Quality (HSEQ) framework facilitates environmentally sustainable oil field operations. The discussion employs existing literature, industry practice, and qualitative logic to cover four key themes:

1. Health & Safety Measures that Reduce Environmental Risk
2. Quality Management as a Catalyst for Resource Efficiency
3. Environmental Protection Strategies Embedded in HSEQ
4. Sustainability Outcomes of Comprehensive HSEQ Implementation

Theme 1: Health & Safety Measures that Reduce Environmental Risk

While one of the primary principles of HSEQ is focused on ensuring that people stay safe & healthy (from either injuries sustained at work or ill-health resulting from work), the focus on worker health and safety needs to also ensure that the environment is protected. In addition to being one of the greatest risks to personnel, oil fields create significant risk to the environment as well. Unsafe work practices (e.g., not handling drilling fluids properly, not storing hazardous materials safely, and not training employees properly) will often lead to an environmental disaster (e.g., oil spills, contaminated land, or contaminated groundwater; Mohamed & Antunes, 2020).

Safety Training reduces the likelihood that incidents resulting in damage to the environment will occur. By training employees to identify hazards, contain spills, and segregate waste, employees have an increased ability to prevent incidents that adversely impact ecosystems. This is consistent with one of the recurring principles of sustainability: "prevention is better than cure".

Another aspect of mitigating damage to the environment is to monitor the health of your employees. Employees who experience fatigue, stress, and/or exposure to hazardous substances will be more likely to make mistakes in the performance of their job and these mistakes can have a significant negative impact on the environment. Thus, by monitoring the health of your employees, an organization can have an indirect impact on preventing incidents that may damage the environment by ensuring that employees are able to perform their job safely.

By integrating health & safety initiatives into their environmental strategy, oil companies are able to decrease the number and severity of environmentally damaging incidents, which creates a direct correlation between worker health and ecological health.

Theme 2: Quality Management as a Catalyst for Resource Efficiency

In many circles, the Quality piece of HSEQ is sometimes viewed simply through the lens of product specifications or compliance to standards. In actuality, effective Quality Management has a significant impact on both resource efficiency and waste minimization, both of which are critical to achieving sustainability within oil fields.

A properly constructed Quality Management System (QMS) develops and reinforces Standard Operating Procedures (SOPs) in order to minimize the amount of material that is wasted. A good example includes the use of precise methods of drilling in order to minimize the unnecessary removal of drilling muds as well as reduce the amount that will have to be disposed as waste. Maintenance procedures for machinery are another example, where the proper use of machinery can prevent the unnecessary release of oil and energy losses (Mendoza et al., 2021).

Quality assurance also facilitates the use of continuous improvement cycles, such as the Plan–Do–Check–Act (PDCA) method, by evaluating and improving environmental performance. For example, through a quality audit, management may determine that using a higher grade lubricant for machinery will extend the life of that machinery and produce less toxic waste.

Furthermore, supplier quality control within HSEQ guarantees that the materials being purchased are environmentally friendly – i.e. biodegradable lubricants or low-emission generators – thus reducing the ecological footprint of oil field operations.

Therefore, it can be concluded that Quality Management is not a separate function of a company, but rather it provides a means of integrating resource efficiency into all areas of oil field operations and increasing the environmental aspect of sustainability.

Theme 3: Environmental Protection Strategies Embedded in HSEQ

Sustainability is most closely associated with the environmental aspect of HSEQ, but the extent to which it is effective relies on how well it has been incorporated into operational culture. Oil field environmental protection encompasses pollution prevention, resource conservation and restoration of ecosystems.

Pollution prevention efforts such as zero-discharge policies, air emissions controls, and wastewater treatment systems are implemented to ensure contaminants do not leave the oil field. An example of this would be the vapor recovery units (VRUs) utilized to capture volatile organic compounds (VOCs) from crude oil storage tanks and thereby reduce greenhouse gases (Chmielarz et al., 2019).

Resource conservation is achieved through the use of closed-loop drilling systems that recycle drilling fluids used in the drilling process and minimize water usage. Of particular importance, since many oil fields are located in arid regions, is water management. Implementing produced water treatment for reuse in operations results in a significant reduction of the amount of fresh water withdrawn and aligns with the goal of global water stewardship.

Ecosystem restoration activities such as re-vegetating disturbed land and soil remediation after well decommissioning ensure that the activities conducted in oil fields result in a smaller long-term environmental footprint. In addition to being good environmental practice, these efforts demonstrate a company's commitment to corporate social responsibility (CSR) fulfilling those commitments while also enhancing community trust.

Companies can operationalize sustainability rather than having it be an afterthought by embedding environmental protection into HSEQ.

Theme 4: Sustainability Outcomes of Comprehensive HSEQ Implementation

If HSEQ is applied in a holistic way, the real-world results of HSEQ sustainability show through the operational/environmental/social changes, even when we cannot provide quantifiable data.

For example, oil fields that have well-established HSEQ systems are much less likely to have an environmental incident than those without one. Qualitative reviews of 10 oil fields that have implemented HSEQ as part of their operation found that they have had fewer spills, lower emissions, and better waste management (Olsen & Hansen, 2020).

The second example of how HSEQ sustainability produces tangible benefits is through improved regulatory compliance. This generally results in reduced chances of fines from the government due to non-compliance, as well as reduced risk of being shut down due to non-compliance, and improved reputation among stakeholders. Finally, the third example of how HSEQ sustainability produces tangible benefits is through improved stakeholder relationships. There is a direct correlation between the level of visible environmental care shown to them and the level of support the communities around oil

fields will provide for the continued operation of those fields. This social license to operate is a very valuable asset to the oil industry and even more so in politically sensitive areas of the world.

Finally, the implementation of comprehensive HSEQ processes on an operation will also create savings for companies from an economic perspective, in addition to the aforementioned ecological/social responsibilities. Energy conservation as a result of efficient energy systems, reduced waste of resources, and the avoidance of cost associated with cleaning up environmental damage are all ways to create long-term savings as a result of HSEQ sustainability.

Integrating Themes into a Holistic Perspective

Health and Safety, Quality Management, Environmental Protection and Sustainability are individual themes but are connected to one another. H & S protocols are designed to protect against environmental incidents. Quality systems enable the efficient use of resources. Environmental strategies protect our ecosystem. They all work together to create sustainable outcomes.

Moreover, the inter-relationship between the four interconnected functions is such that we should not view HSEQ as independent functional areas but rather as one governance framework supporting sustainable operations within an oil field. Thematic analysis has proven that HSEQ is adopted within organisational culture not just as a compliance requirement: thus, becoming an agent of change for environmentally responsible stewardship of oil and gas development.

Case Examples

Case A — BP: from crisis responses to embedding HSEQ in systems and design

Motivation and background: BP's development is an example of how large companies can use their experiences during a crisis (such as the Deepwater Horizon event) to create lasting improvements in their HSEQ (health, safety, environment, and quality) and environmental systems. BP's sustainability and public disclosures show their investments in leak detection and repair (LDAR) programs, flaring reduction projects, and the use of HSEQ to define the design and procurement of projects (BP 2023; BP 2021).

Operational measures and results: BP states that they conduct front-end engineering, which incorporates HSEQ into the design of projects, so that they do not need to spend

large amounts of money to retrofit them and have less risk of incidents (BP 2023). BP 2021 explains that LDAR, remote sensing for methane detection, and improved flaring management are examples of operational initiatives that lower emissions from the operations and the environmental impact of the operations.

Importance of the information: BP confirms that in order to prevent environmental damage, HSEQ must be integrated with engineering, procurement and project management rather than relying solely on mitigation after an incident occurs. One way for an organization to create accountability in the community is by providing public progress reports so that stakeholders can evaluate whether the organization is achieving its environmental goals (BP 2023; BP 2021).

Case B — Shell: investing in preparedness, HSE culture, and remediation

History: The Shell corporate parent has mature health, safety and environmental (HSE) systems and a long history of maintaining extensive contingency plans for threats throughout the world. However, many examples of past controversies and enforcement actions have demonstrated that Shell needs to maintain its commitment to continuous improvement in HSE (Shell, 2020).

Operational experience: Shell's past performance has led to the development of three key operational principles

(1) that require the company to invest in regional capacities for response (response teams and prepositioned equipment) to ensure a shorter response time and reduce the likelihood of environmental damage;

(2) that HSE will be routinely integrated into operations and contracting strategies; and

(3) that incident investigations will be used to create improvements in both systems and culture (Shell, 2020).

Controversy as a catalyst for evolving towards higher levels of HSEQ performance: The external (legal, regulatory, and civil society) pressure on Shell has served to accelerate the company's remediation and prevention investments, providing evidence that external

accountability mechanisms can be effective means of catalyzing higher levels of HSEQ performance improvement (Miller & Hart, 2018).

Case C — Aker BP and North Sea peers: treating flaring and energy use as HSEQ KPIs

Introduction: The operators working in the North Sea (Aker BP for example) have identified reducing flaring and managing energy as part of their main HSEQ objectives due to strict regulation and effective climate governance (Aker BP, 2021).

Methods of Implementation: Aker BP demonstrates that closed-flare systems, operational discipline in order to safely avoid flaring when possible, and specific KPIs for both flaring intensity will both limit GHG emissions and limit the number of air pollutants generated by the facility (Aker BP, 2021). These approaches combine engineering solutions, operating procedures and monitoring into achieving clear environmental objectives and targets that represent the classic elements of HSEQ.

Transferability: This example of Aker BP establishes how flaring and energy intensity can be operationally achievable HSEQ targets. For operators in other locations, there is an opportunity to embed these HSEQ operational KPIs into HSEQ dashboards that convert their respective policies into action while enabling an assessment of the environmental performance over time (Aker BP, 2021; BP, 2023).

Cross-case synthesis: effective HSEQ practices for environmental benefit

The identification of several key HSEQ practices demonstrates how the oil and gas industry is developing its environmental stewardship through a variety of means including:

1. Integrated Documentation and Governance: The development of a living health, safety, and environmental (HSE) manual that is continuously supported by field implementation and audits will create a consistent level of practice across operating locations (Shell, 2020).

2. Design Stage HSEQ Integration: Incorporating requirements for HSEQ into engineering and procurement activities at the design stage reduces the need for retrofits and the risk of incidents (BP, 2023).

3. Key Performance Indicators: The operational performance of flaring, reuse of produced water, performance of leak detection and repair (LDAR) and frequency of spills provides a direct means of translating HSEQ into priorities for action (Aker BP 2021; BP 2021).

4. Preparedness and Response Capabilities: The maintenance of regional response assets and conducting drills on a regular basis can effectively reduce the magnitude of incidents (Shell, 2020).

5. Transparent Reporting of Environmental Social Governance (ESG) alignments: Public reporting on sustainability affords stakeholders with an opportunity to hold operations accountable for their environmental performance; facilitates the availability of capital that is willing to support environmental stewardship (BP 2021).

Suggestions and Recommendations

The review of HSEQ performance by the oil and gas sector, particularly through the case studies has revealed that while much progress has occurred in integrating sustainability and safety into their operations, there are still many opportunities which require focus and attention from an HSEQ perspective to strengthen environmental stewardship, health and safety in the workplace and quality assurance in the oil and gas industry.

Strengthening Environmental Management Practices

1. Harnessing the Latest Technologies for Environmental Monitoring

Oilfields should use technology to actively monitor the environmental effects of oil and gas exploration. In the oil and gas industry, we must use real-time monitoring technology, including satellite detection for spills, and IoT-enabled sensors for air and water quality, to detect potential hazards (Al-Kaabi & Ozyer, 2021). This approach would allow for timely intervention to limit the impact of oil and gas operations on the environment.

2. Implementing a Zero Discharge Policy

A "Zero Discharge" policy requires that all wastewater generated by the extraction and processing of oil and gas be treated and reused on-site. The implementation of a zero

discharge policy would substantially reduce the risk of contamination from oil and gas operations (Ahmad et al., 2020).

3. Utilizing Renewable Energy Sources in Operations

Oil companies should incorporate renewable energy sources such as solar and wind for non-critical sites to lower their greenhouse gas (GHG) emissions. Additionally, during operations conducted in desert environments, hybrid energy systems such as solar with diesel back-up can be utilized to power safety equipment and mobile offices.

Enhancing Health and Safety Protocols

1. Behavioral Safety Programs

While technical controls are essential, creating a culture of safety with employees is just as important (Reason 2016). Therefore, one way for oil companies to create this culture is by conducting Behavior-Based Safety (BBS) Programs in which employees are given training on how to observe, report, and correct unsafe behaviors before incidents happen.

2. Mental Health Support for Employees in the Field

Employees working in remote oil fields may experience mental strain from their jobs; therefore, implementing mental health services, such as mental health counselling and rotate breaks off work, as well as providing stress management workshops, should improve the overall health of employees (Searle & Rice 2021).

3. Digital Simulation Training

Using virtual reality (VR) or augmented reality (AR) as a digital simulation tool to train employees on safe procedures will provide better emergency preparedness for any incident, such as a fire, blowout, or chemical spill, because it can simulate those events in a safe environment (Gao et al. 2022). Therefore, the use of simulation training as opposed to only using traditional classroom training will greatly enhance an employee's ability to carry out his/her duties if an emergency incident occurs.

Strengthening Quality Management

ISO 9001 and ISO 14001 Systems Integration

Despite companies having different ISO 9001 and ISO 14001 systems, creating a combined QMS (Quality Management System) that includes both ISO systems will help to eliminate redundancy in processes, and ensure that both quality and environmental aspects of the organization are continuously improved. (International Organization for Standardization 2018)

Supplier Quality Assurance Audit Programs

Due to the reliance on contractors for developing oil fields, it would be beneficial for companies to conduct mandatory audits of all contractors prior to hiring them for any work, so that all materials supplied are in compliance with the company's sustainability objectives. (Rahman & Subramanian 2020)

Continuous Improvement (CI) Feedback Systems

Establishing an organization-wide CI feedback mechanism (i.e., incident reporting systems), where each incident, near miss, and process deviation is reviewed, remedied, and resubmitted for review within 30 days (or less if critical) will facilitate a proactive approach to maintaining quality control.

Recommendation

Recommendations from the study for oil and sector are as follows;

- The following customized recommendations can assist the oil and gas industry in achieving improved environmental performance and long-term sustainability in line with the findings of the Prepared For Government (Vancouver, British Columbia) headquarters oil and gas case study analysis.
- The oil and gas industry has a number of environmental/safety units, many companies have seen the benefit of creating a dedicated sustainability division to coordinate green initiatives across the industry to monitor key performance indicators (KPIs); and prepare annual sustainability reports.
- Using low-emission drilling platforms, generators, and vehicles that meet Tier 4 emissions standards will significantly decrease nitrogen oxide and particulate matter emissions throughout the oil and gas sector.

- Expand environmental training programs for all employees/contractors/site managers to cover biodiversity conservation, waste segregation, energy conservation practices, and emergency response in the case of an environmental incident.
- At all high-risk locations, consider installing double-walled pipelines and secondary containment systems; and automatic shutoff valves on all high-risk locations to reduce the occurrence and severity of crude oil and chemical spills.
- Collaborate with academic institutions and international research organizations to develop cost-effective, environmentally-friendly technologies, including bioremediation solutions, that are most suited to specific regions of operation.
- In the next 15-20 years, the oil and gas sector should diversify its business model by exploring investments in renewable energy projects, carbon capture and storage (CCS) facilities, and production of green hydrogen.
- Each year, the organization will release Sustainability Reports in accordance with GRI Standards to allow for comparison of global performance against competitors and will attract investment from ESG-focused investors.
- To minimize the impact of waste into landfills, the organization will establish circular economy initiatives, e.g. recycling soil and mud from drilling and repurposing as construction material or road base.
- The organization will implement Spill Prevention Task Forces at the national level to perform continuous risk assessments, utilize drone technology to monitor pipelines, and utilize Internet of Things (IOT) technology for real-time detection of leaks throughout operations.
- The organization will create Green Procurement Policies which require all suppliers to be Green Certified and contain verified, low-carbon materials that can be recycled; and meet or exceed all applicable International Environmental Standards.
- The organization, and sector leaders, will develop Carbon Reduction Road Maps that include five-year interim targets for reducing flaring, improving energy efficiency, and minimizing methane emissions across all operations.
- The organization will provide stable funding for community-based Environmental Monitoring Programs that involve stakeholder participation in reporting air quality, water quality, and noise pollution surrounding extraction and processing of raw materials.

- Create a collaborative Industry-wide Fund for Environmental Related Innovations to support funding pilot projects for produced water recycling, solar powered wellheads, and environmentally friendly techniques for drilling.
- The organization will complete third-party Environmental Audits at every major operating location every two years. All audit results and corrective action plans will be publicly available to provide transparency and encourage continuous improvement.

Conclusion

This research concludes that there exists an ethical responsibility for companies to implement an effectively managed HSEQ system within the oilfield industry of high-risk and high-impact sectors, such as oil and gas exploration and production. The synthesis of scholarly sources, with theoretical and practical evidence, demonstrates that having an HSEQ framework that is both comprehensive and effectively implemented is crucial for achieving environmental sustainability, increasing operational efficiency, and ensuring compliance with regulations.

The main theme of the study identifies significant interrelations among the four elements that comprise the HSEQ system. The Health and Safety systems provide protetion for employees from workplace hazards and subsequently reduce the number of workplace accidents, and costs associated with the medical treatment of injured employees, and downtime resulting from such events. The utilization of ISO 14001 Environmental Management Systems (EMS) ensure that the extraction of natural resources is done in a manner that minimizes the potential for pollution; properly manages waste generated from resource extraction; and seeks to reduce the carbon footprint of resource extraction operations. Quality Management processes validate that the processes and products produced meet operational standards, and thereby reduces the potential for operational waste, defects and inefficiencies which would negatively affect the environment or pose a safety risk. When utilized in conjunction with one another, they produce a continuous cycle and improvement from one area assists in the improvement of the others.

A case study examining the oil industry has uncovered several examples of companies following through on their commitment to HSEQ. The various ways that these companies have implemented their initiatives from the development of ISO-certified environmental management systems and the establishment of spill prevention plans and emergency response procedures, to the use of environmentally sustainable drilling technologies demonstrate that companies can operate profitably without sacrificing their environmental commitments. The company's investments in employee training, safety drills and simulations, monitoring environmental impacts, and engaging with communities further illustrate that the success of implementing HSEQ is dependent upon both human capital and collaboration among stakeholders.

The above findings support the principles associated with Systems Theory and the Triple Bottom Line framework. According to Systems Theory, oilfield operations are complex dynamic webs of interconnected relationships between all variables associated with operations including environmental impact, safety, and quality. Consequently, to avoid a systemic failure, there must be integrated management so that these various components work cohesively together. According to the Triple Bottom Line framework, organisations must achieve a balance between economic growth, environmental stewardship, and social responsibility a balance that is difficult but essential in the extractive industries.

Research indicates a number of significant gaps and obstacles still exist for many oil and gas companies today, particularly those operating within developing countries. Many companies in these countries continue to overcome weak regulations, inadequate capital investment in environmental technology, and insufficient workforce training to reach compliance regarding HSEQ (Health - Safety - Environment - Quality) regulations that would produce a more sustainable and socially responsible method of extracting oil and gas from the earth. Furthermore, climate change and the world's transition toward renewable energy provide extra urgency to transforming practices within the oil field. Pakistan, which relies heavily on fossil fuels for the vast majority of its energy, would greatly benefit by introducing an aggressive HSEQ framework into oil field operations not only to create a more sustainable and socially acceptable extraction process, but also to significantly enhance both domestic and international credibility.

Through the evidence provided, it is clear that the integration of HSEQ is not only a compliance issue; rather, it can be viewed as a value-generating activity that has benefits to each of the environmental, social and economic areas of the business. By fostering a

safe work environment, reducing the environmental waste of the operation, and providing a high-quality product, oil field companies can build long-term resilience, reduce operational risks, and build trust with all stakeholders. In addition to developing HSEQ systems, companies that are considering developing and enhancing their current HSEQ systems through continued capital investment in advanced monitoring technologies for the environment, integrating renewable power sources into oil field operations, and openly reporting to stakeholders, would not only be in alignment with the UN Sustainable Development Goals, but would also position themselves as leaders in sustainable resource management in their part of the world.

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