

Embracing Health, Safety, and a Greener Environment in the Construction of Offshore Structures

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Abstract

Offshore infrastructure (oil and gas platforms, offshore wind farms, subsea cables, ports, and associated works) plays a vital role in energy, communications, and trade. However, construction activities offshore create complex safety, public health and environmental risks from worker injuries and exposure to hazardous substances, to marine pollution and ecosystem damage with downstream human health effects. This paper reviews the hazards, regulatory and management frameworks, lessons from major incidents, and practical measures to enhance safety during offshore construction. It presents a systems approach combining robust safety and environmental management systems (SEMS), risk-informed design and planning, contractor governance, environmental monitoring, emergency preparedness, and public health surveillance. This paper explores strategies for embracing health, safety, and a greener environment during offshore construction, drawing upon international standards, industry best practices, and lessons from past incidents. It argues for a holistic framework where occupational safety and environmental stewardship are mutually reinforcing, ensuring sustainable offshore development. The paper also synthesizes literature on occupational safety, environmental management, and regulatory frameworks, while drawing lessons from case studies such as the Deepwater Horizon disaster. Findings highlight the importance of prevention-by-design, robust health and safety management systems, eco-friendly technologies, and community engagement. The paper concludes with recommendations for policy, practice, and continuous improvement aimed at creating offshore projects that safeguard both people and the planet. The result is a set of actionable recommendations aimed at protecting workers, coastal communities and marine ecosystems while enabling safe deployment of offshore infrastructure. Professionals in civil engineering may enhance project results and support sustainable development by taking a proactive approach to health, safety, and environment (HSE).

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INTRODUCTION

Offshore construction plays a vital role in the energy supply, trade, and global connectivity. The scale of offshore infrastructure has expanded significantly in recent decades, from oil and gas platforms to offshore wind farms and subsea communication cables. However, this expansion presents dual challenges: (1) the protection of human health and safety in hostile marine environments, and (2) the preservation of fragile marine ecosystems [1]. Construction of offshore structures is essential for global energy, communication, and trade. However, these processes expose workers, communities, and

marine ecosystems to significant health, safety, and environmental (HSE) risks. As demand for offshore infrastructure continues to grow, it is crucial to adopt integrated approaches that simultaneously protect human health, enhance workplace safety, and preserve the environment. Offshore structures such as oil and gas platforms, wind farms, and subsea pipelines play pivotal roles in meeting global energy and economic needs. However, the offshore construction environment is uniquely hazardous owing to harsh weather, deepwater operations, heavy lifting, and handling of hazardous materials. These risks not only threaten worker safety but also jeopardize marine biodiversity and the public health of coastal communities. Traditionally, safety and environmental protection have been treated separately. Global sustainable development goals (SDGs) and international standards emphasize the need for integrated approaches that reduce risks while minimizing the ecological footprint. This study examined how HSE sustainability can be embraced in offshore construction projects.

Health Considerations in Offshore Construction

Protecting worker health is fundamental to sustainable offshore projects.

1. *Occupational health risks*: Offshore workers face chemical exposure (oil vapors and solvents), physical risks (falls, noise, and vibration), and psychosocial challenges (fatigue and isolation).
2. *Health surveillance*: Regular medical examinations, mental health support, and occupational hygiene monitoring (air quality, noise, and ergonomic conditions) safeguard worker well-being.
3. *Medical preparedness*: Offshore sites should have trained medical personnel, telemedicine access, and emergency evacuation (medevac) arrangements.

By embedding health surveillance and medical preparation into project planning, offshore construction can prevent long-term occupational diseases and ensure a fit and resilient workforce. Ensuring worker health and safety is the cornerstone of responsible offshore construction. Owing to the complex, high-risk marine environment, occupational health, and safety (OHS) measures must be proactive and robust. Offshore construction is inherently hazardous: operations occur in a dynamic marine environment, use heavy lifting and high-energy equipment, involve complex vessel and platform logistics, and often handle hazardous materials (fuels, hydraulic fluids, and chemicals). Worker safety, accidental releases to the sea or air, and chronic environmental impacts are interconnected: harm to ecosystems can translate to human health effects (through contaminated seafood, airborne pollutants, or disrupted livelihoods), while large incidents impose long-term socioeconomic and health burdens on coastal communities. This study synthesizes best practices from standards, regulatory guidance, and case studies to propose a holistic strategy for enhancing safety and protecting public health and the environment during offshore construction.

Historically, the offshore sector has been marked by catastrophic incidents, such as Piper Alpha (1988) and Deepwater Horizon (2010) [2], which have revealed the consequences of inadequate safety and environmental safeguards. These incidents demonstrate that HSE issues are interlinked rather than isolated concerns [2]. Protecting workers from injury and illness goes hand in hand with preventing pollution and biodiversity loss. The purpose of this study was to explore how offshore construction can embrace health, safety, and greener environmental practices in an integrated framework. It argues that by aligning occupational safety systems with environmental sustainability, offshore projects can reduce risks, comply with international regulations, and contribute positively to global SDGs.

LITERATURE REVIEW

It is anticipated that the conclusions of this research will be a useful tool for legislators, project managers, and construction industry stakeholders to prioritize HSE factors to achieve safer, more effective, and ecologically friendly projects.

Construction of vital infrastructure, including buildings, bridges, roads, and water systems, is the responsibility of the civil engineering sector, which is a pillar of national development. However, industry is intrinsically linked to serious hazards to the environment, public health, and safety. A

significant percentage of occupational fatalities and injuries worldwide is caused by accidents involving construction, highlighting the urgent need for effective HSE management systems. In procedures are essential to safeguard employees, reduce environmental effects, and complete projects quickly and sustainably. HSE management must consider the environment, particularly in light of climate change. Activities involving civil engineering projects can produce trash, release greenhouse gases, and disrupt ecosystems. Reducing the ecological footprint of construction projects requires the use of ecologically friendly practices such as energy-efficient designs, green building technology, and waste recycling (UNEP, 2021) [1]. Additionally, incorporating environmental management into project planning supports global sustainability objectives, such as the UN's SDGs. Figures 1 and 2 show typical HSE service training. Prior to starting data collection, approval from the appropriate institutional review board was requested [3].

A useful technique for reducing environmental hazards and guaranteeing adherence to sustainability objectives is the incorporation of Environmental Impact Assessments (EIAs) into project planning and implementation. HSE procedures may become more effective and efficient when paired with cutting-edge technology, such as drones, wearable safety gear, and Building Information Modeling (BIM). These improvements reduce expenses related to accidents, fines, and project delays, in addition to improving safety and environmental performance [4]. Despite these developments, cultivating a culture of responsibility and ongoing improvements are crucial to the success of HSE frameworks. To close the current gaps, stakeholders in Nigeria's civil engineering industry must cooperate. This entails making technology solutions reasonably accessible, funding employee training initiatives, and enforcing more stringent adherence to environmental and safety regulations. Additionally, involving stakeholders and the community in EIA procedures helps promote confidence and guarantees that projects meet environmental and socioeconomic standards [4].

Offshore Construction Risks and Health Implications

Research indicates that offshore construction workers are exposed to physical hazards (falls, heavy lifting, confined spaces), chemical hazards (hydrocarbons and solvents), and psychosocial stressors, such as fatigue and isolation. Prolonged exposure without adequate safeguards can result in acute injuries, occupational diseases, and reduced productivity. Therefore, occupational health surveillance and medical preparedness are essential in these environments [4].



Figure 1. HSE (Health and Safety Environmental) service training.

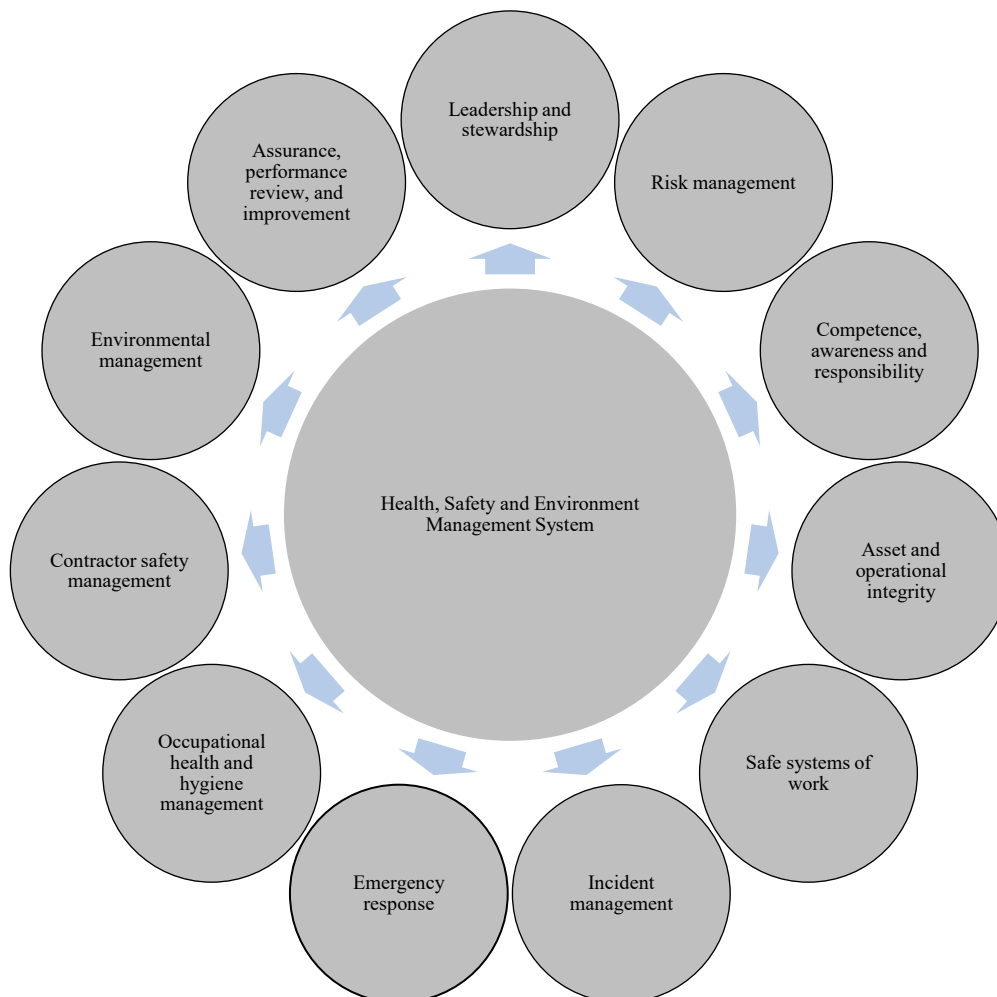


Figure 2. HSE environmental management system.

Safety Frameworks in Offshore Construction

The safety of offshore construction is typically governed by international and national standards. ISO 45001 provides a global framework for occupational health and safety management systems, emphasizing hazard identification and risk reduction [4]. The American Petroleum Institute's Recommended Practice 75 (API RP 75) specifies safety and environmental management systems (SEMS) for offshore operations with an emphasis on risk assessment, contractor management, and emergency preparedness [5]. Studies suggest that projects implementing SEMS experience lower incident rates and improved safety culture [6, 7].

Environmental Concerns and Greener Approaches

The marine environment is highly sensitive to construction impacts such as oil spills, noise pollution, and seabed disturbance. The International Maritime Organization (IMO) enforces MARPOL regulations to prevent marine pollution from ships, including waste and oil discharge [2]. Meanwhile, renewable energy projects, such as offshore wind farms, have pushed for greener construction methods, including recyclable materials, low-emission vessels, and noise reduction technologies such as bubble curtains [4].

Integrated HSE Approaches

The recent literature highlights the growing shift toward integrated HSE management systems. Scholars argue that combining ISO 45001 (safety) with ISO 14001 (environmental management) creates a unified framework that reduces duplications and ensures consistent risk management [8, 4].

Moreover, digital technologies, such as drones and digital twins, provide real-time monitoring of both safety and environmental performance, enhancing transparency and efficiency [9].

METHODOLOGY/APPROACH

This study adopted a qualitative integrative review methodology. The sources were peer-reviewed journals, international standards, government reports, and case studies. Emphasis was placed on:

1. Occupational health and safety practices in offshore construction.
2. Environmental management and sustainable construction methods.
3. Lessons learned from past offshore incidents.
4. Integration of HSE systems into a holistic framework.

Data were synthesized into thematic areas—health, safety, environment, integration, and recommendations—to produce a comprehensive set of strategies for embracing HSE in offshore construction.

Safety Measures in Offshore Construction

Safety management in offshore environments relies on robust systems and preventive strategies:

1. *Safety management systems*: Adoption of international frameworks such as ISO 45001 (Occupational Health and Safety) and API RP 75 (Safety and Environmental Management Systems) ensures structured risk management.
2. *Prevention-by-design*: Incorporating modular pre-fabrication, fall protection systems, and automation reduces hazardous offshore activities.
3. *Training and competence*: Comprehensive induction and refresher training in confined space entry, firefighting, rescue, and emergency evacuation are crucial.
4. *Human factors management*: Fatigue control, ergonomic designs, and participatory safety programs enhance decision-making and reduce human error.

Emphasizing safety not only reduces accident frequency but also prevents large-scale disasters that can have both human and environmental consequences.

Environmental Sustainability in Offshore Construction

The construction of offshore infrastructure must embrace greener practices to minimize ecological damage.

- *Pollution prevention*: Strict adherence to MARPOL regulations, zero discharge policies, and proper waste management systems reduce marine contamination.
- *Energy efficiency*: Use of low-emission vessels, hybrid machinery, and renewable power sources during construction lowers the carbon footprint.
- *Biodiversity protection*: Early ecological surveys, habitat mapping, and timing of construction activities outside sensitive breeding or migration seasons help protect marine life.
- *Noise and vibration control*: Methods such as bubble curtains during piling operations reduce the impact on marine mammals.
- *Sustainable materials*: Employing recyclable steel, corrosion-resistant alloys, and low-toxicity coatings prolongs service life while reducing environmental hazards.

By embracing greener methods, offshore projects align with climate-action goals and marine conservation efforts.

Integrating Health, Safety, and Environment

Health, safety, and environmental goals are interdependent and must be managed holistically:

1. *Unified HSE frameworks*: Combining ISO 45001 (safety) with ISO 14001 (environment) ensures that risks are managed together, rather than in silos.

2. *Digitalization and monitoring*: Real-time sensors, drones, and digital twins allow continuous safety and environmental monitoring.
3. *Emergency preparedness*: Drills that integrate worker rescue with environmental spill containment improve resilience.
4. *Stakeholder engagement*: Transparent reporting, community consultations, and collaborative monitoring build public trust and improve compliance.

Integration ensures that worker protection and environmental care reinforce each other, thereby reducing both occupational hazards and ecological damage.

HEALTH AND SAFETY MEASURES

1. *Adopt robust HSE management systems* (e.g., ISO 45001, API RP 75): Embed hazard identification, risk assessment, and management of change into all project stages [10].
2. *Design for safety (prevention-by-design)*: modular fabrication onshore to minimize risky offshore activities, safe access walkways, fall protection systems, and automation to reduce human exposure.
3. *Worker training and competence*: Regular training in confined space entry, firefighting, emergency evacuation, and mental health awareness.
4. *Medical support*: Offshore medical facilities, medevac arrangements, and health surveillance programs for workers.
5. *Human factors and fatigue management*: adequate rest hours, ergonomic equipment design, and psychological well-being support.

Environmental Protection (Greener Construction)

1. *Eco-friendly materials and technologies*: Corrosion-resistant, recyclable steel and low-toxicity coatings are used to reduce maintenance and pollution.
2. *Energy efficiency*: Hybrid or low-emission vessels and renewable energy integration during construction (e.g., using offshore wind power for operations).
3. *Waste and emissions control*: Compliance with MARPOL, ‘zero discharge’ policies where possible, proper segregation and treatment of waste, and carbon footprint tracking.
4. *Noise and vibration mitigation*: Bubble curtains or vibro-driving are used instead of impact piling to protect marine mammals during foundation installation.
5. *Biodiversity protection*: Careful site surveys to avoid sensitive habitats (reefs, seagrass, and bird routes) and timing work outside the breeding and migration seasons.

Integration of Health, Safety, and Environmental Goals

1. *Safety and sustainability audits*: Integrate HSE audits with environmental performance reviews.
2. *Digital monitoring*: Real-time sensors, drones, and digital twins are used to monitor worker safety and environmental indicators (emissions, spills, and turbidity).
3. *Emergency preparedness*: Joint safety drills that include environmental responses (e.g., spill containment and worker rescue).
4. *Community and stakeholder engagement*: Involve coastal communities, regulators, and NGOs in planning, sharing environmental monitoring data, and ensuring transparency.
5. *Continuous improvement*: Learn from past incidents (e.g., Deepwater Horizon) by enhancing preventive measures and ensuring lessons are applied across sectors [2].

Health and Safety Practices in Offshore Construction

Occupational Health Considerations

Offshore workers are exposed to a wide range of hazards. Physical hazards include falls from heights, exposure to extreme weather, and heavy machinery accidents. Chemical risks come from hydrocarbon vapors, welding fumes, and solvents used in the coatings. Psychosocial risks, such as fatigue from long shifts, isolation, and stress, can also compromise mental health.

Mitigating these risks requires:

1. *Medical surveillance programs*: Regular health checks to identify early signs of occupational illnesses.
2. *On-site medical facilities*: Offshore installations should include first-aid stations, telemedicine access, and evacuation protocols.
3. *Mental health support*: Programs to address fatigue, stress, and isolation.

Safety Management Systems

Safety frameworks such as ISO 45001 emphasize hazard identification, risk assessment, and continuous improvement (ISO 2018). A strong safety management system (SMS) includes:

1. *Permit-to-work systems*: Formalized approvals for high-risk tasks such as confined space entry or hot work.
2. *Emergency preparedness*: Drills covering fire, oil spill, and evacuation scenarios.
3. *Contractor management*: Verification of contractor compliance with safety standards and competency assessments.

Prevention-by-Design

Engineering solutions are central to reducing offshore risk. Pre-fabrication and modular construction allow most work to be completed onshore, reducing offshore exposure. Designs that incorporate fall arrest systems, guardrails, and automated handling equipment further limit hazards [1].

Training and Competency

Training is critical to ensure that workers understand and manage risks. Programs should include survival at sea, firefighting, helicopter underwater escape training (HUET), and equipment handling. Refresher training ensured continuous competence.

Environmental Sustainability Measures

Sustainable offshore construction minimizes ecological damage while supporting the global transition to greener energy.

Pollution Prevention and Waste Management

Marine pollution is one of the greatest risks during offshore construction. Strict adherence to MARPOL regulations is required to manage bilge water, sewage, and oil residues [2]. Best practices include:

- Zero discharge policies where possible.
- Segregation and treatment of waste on vessels.
- Spill prevention measures such as double-hulled fuel tanks and containment bunds.

Noise and Vibration Reduction

Piling and drilling can produce underwater noise, which is harmful to marine mammals. Techniques such as bubble curtains, vibratory piling, and seasonal restrictions help mitigate impacts [4].

Sustainable Materials and Energy Use

Using corrosion-resistant alloys and recyclable steel extends the service life and reduces maintenance-related emissions. Energy-efficient construction vessels and hybrid power systems have lower carbon footprints. Offshore renewable energy projects often integrate green supply chains to ensure sustainability.

Biodiversity and Habitat Protection

EIAs should be conducted prior to construction. Strategies include rerouting around sensitive seabed, avoiding coral reefs, and scheduling outside the breeding and migration seasons [9].

Integrated HSE Frameworks

Unified Management Systems

Rather than treating health, safety, and the environment as separate concerns, integrated management systems align them into a single framework. Combining ISO 45001 (safety) with ISO 14001 (environmental management) ensures a consistent approach to risk management [8].

Digital Technologies

Technological innovations support integrated HSE practices:

- *Digital twins*: Simulate offshore operations to predict safety and environmental risks.
- *Drones and Remotely Operated Vehicles (ROVs)*: Conduct inspections without exposing workers to hazardous conditions.
- *Real-time sensors*: Monitor emissions, spills, and structural integrity.

Emergency Response Integration

Emergency drills should address both human safety (evacuation and rescue) and environmental protection (oil spill responses). Integration ensures the coordinated and efficient use of resources.

Case Studies

Deepwater Horizon (2010)

The Deepwater Horizon blowout has been the most significant offshore disaster in recent years. Eleven workers died, millions of barrels of oil spilled, and long-term ecological and public health impacts were recorded [2]. Investigations have revealed systemic failures in risk management, contractor oversight, and safety culture. This case emphasizes the importance of prevention, monitoring, and accountability.

Offshore Wind Construction Projects

Offshore wind projects are positive examples of greener construction. In Europe, bubble curtain technologies have been deployed to reduce the noise impacts during piling. Furthermore, operators increasingly use hybrid vessels to reduce emissions. Transparent environmental monitoring reports are shared with stakeholders, promoting accountability and trust [4].

Regulatory and Standards Framework (Overview)

Key international and industry standards and conventions provide the foundation for safe offshore operations:

1. *Occupational health and safety management*: ISO 45001 sets requirements for occupational health and safety management systems applicable to construction projects and helps to embed risk management, worker participation, and continual improvement.
2. *Industry SEMS/SEMS-like practices*: The American Petroleum Institute recommended Practice 75 (API RP 75) and related documents prescribe safety and environmental management systems specifically for offshore operations, including risk assessment, management of change, and contractor control. Recent editions have extended their applicability to contractors and renewables [10].
3. *Marine pollution and environment conventions*: The IMO's pollution prevention instruments (MARPOL and related guidance) and flag/state regulatory regimes govern the prevention of oil, chemical, and waste discharges, and air emissions. National regulators (e.g., EPA, BSEE/BOEM in the U.S.) provide project-level requirements and permits [1].

These frameworks should be treated as minimum baselines, and project-specific risk profiles often justify stricter measures.

Key Hazards and Public Health/Environmental Pathways

Understanding hazard pathways is essential for designing effective interventions. Major hazards during offshore construction include the following.

1. *Major accidents (explosions, blowouts, fires)*: While most accidents are associated with upstream production, construction activities involving drilling, heavy lifting, or hydrocarbon handling can

trigger large incidents with catastrophic environmental consequences. (Design and hazard analysis standards provide mitigation frameworks.)

2. *Operational releases and routine emissions:* Spills of fuel, lubricants, concrete slurry, or chemicals during installation, and air/noise emissions from vessels' engines cumulatively impact marine life and coastal air quality. MARPOL and national rules target these sources.
3. *Worker exposures:* Construction workers can be exposed to physical hazards (falls, struck-by, confined spaces), chemical hazards (hydrocarbon vapors, solvents), and psychosocial risks; these exposures can produce both acute injuries and long-term health effects. ISO 45001 and industrial SEMS emphasize exposure control and medical surveillance.
4. *Ecosystem and food-chain impacts:* Oil spills and chronic contamination can cause direct ecological damage and long-term effects on fisheries and seafood safety, with downstream human health and socioeconomic impacts. Evidence from the Deepwater Horizon spill shows measurable ecosystem and human health consequences for responders and residents.

Lessons from Major Incidents: Why Proactive Safety Matters

The 2010 Deepwater Horizon disaster underlined how a construction/installation-related incident can cascade into massive environmental and public health crises: widespread oil contamination, long-term ecological effects, and adverse health outcomes among cleanup workers and affected communities (respiratory, neurological, and mental health sequelae reported in follow-up studies). These findings reinforce the need for rigorous prevention, rapid containment, and long-term health monitoring after an incident.

CORE ELEMENTS OF AN ENHANCED SAFETY STRATEGY

A resilient program to protect public health and the environment during offshore construction must be multi-layered. The core elements and practical measures are described below.

Project Planning and Design (Prevention-by-Design)

1. *Health-and-safety-by-design:* minimizing working at height, simplifying lifting operations, using modular pre-fabrication to reduce offshore work time, designing spill-resistant fuel and chemical storage systems, and selecting materials with lower toxicity and environmental persistence.
2. *Route and habitat assessments:* Early avoidance of sensitive habitats (coral, seagrass, bird nesting/foraging areas) reduces environmental risks and regulatory friction.
3. *Cumulative impact assessment:* Account for concurrent projects and shipping traffic to reduce aggregate stress in marine systems.

Robust Safety and Environmental Management System

Implementation or alignment with SEMS (e.g., API RP 75) and ISO 45001/ISO 14001 frameworks: hazard identification, risk assessment, management of change, contractor control, incident investigation, and continual improvement. SEMS that explicitly cover contractors and renewables are becoming increasingly available [8].

Detailed Risk Assessment and Conservative Controls

- *Bow-tie and HAZID/HAZOP:* Use structured methods to identify critical controls and recovery measures for high-consequence events.
- *ALARP principle:* Reduces risks to as low as reasonably practicable and document decisions and mitigation.

Contractor Selection, Competence and Supervision

Pre-qualify contractors for HSE performance, verify certifications (e.g., ISO 45001), evaluate safety culture, ensure competency assessments for critical roles, and require contractor SEMS alignment. Independent audits and joint safety committees can align standards across organizations.

Training, Human Factors and Workforce Health

- *Comprehensive induction and refresher training*: For offshore hazards, lifeboats and rescue, confined spaces, permit-to-work systems, and fatigue management.
- *Medical screening and surveillance*: Baseline and periodic health checks and occupational hygiene monitoring (air sampling and noise). ISO 45001 emphasizes worker consultation and participation, which improves uptake.

Environmental Controls and Monitoring

- *Spill prevention and containment*: double-bundling of storage, drip trays, automatic shutoffs, spill kits staged on vessels, and rapid skimming and booms pre-positioned where appropriate.
- *Water and sediment monitoring*: Baseline and periodic sampling for hydrocarbons, dispersant residues, heavy metals, and turbidity during construction.
- *Air and noise monitoring*: especially nearshore works affecting coastal communities or marine mammals.

Emergency Preparedness and Response

- *Site-specific emergency response plans (ERP)*: clearly defined roles, communication, escalation, and integration with national coast guard/response agencies. Drills with realistic scenarios save lives and time during incidents.
- *Medical emergency response*: Medevac arrangements, onboard medical capability, and linkage to onshore hospitals and public health agencies.

Waste Management and Decontamination

- *Zero discharge where practicable*: Segregate and properly treat/landfill wastes and manage hazardous wastes by MARPOL and local regulations. Decontamination protocols for equipment to avoid invasive species transfer and the spread of contamination.

Community and Public Health Engagement

- *Transparency and communication*: Early stakeholder engagement, publicly available environmental monitoring summaries, and established hotlines for complaints or reports can reduce mistrust and facilitate rapid action if issues arise.
- *Health surveillance for communities and responders*: Establish pathways for long-term monitoring of exposed workers and affected populations as part of contingency planning. Lessons from large spills indicate that many health effects may emerge months or years later.

Technology, Digitalization and Remote Monitoring

- *Digital twins and real-time sensors*: For structural loads, emissions and leak detection improve early detection and decision support.
- *Uncrewed systems (Remotely Operated Vehicles (ROVs), drones)*: Reduce personnel exposure during inspections and provide rapid situational awareness.

INSTITUTIONAL AND POLICY RECOMMENDATIONS

1. *Mandate SEMS + certification for major offshore contracts*: Regulators should require documented SEMS implementation (aligned with API RP 75/ISO 45001 principles) and audits as part of permitting to raise baseline performance [8].
2. *Strengthening contractor oversight rules*: Licensing regimes should require primary operators to remain accountable for contractors' HSE performance and ensure transparent reporting.
3. *Establish funded medical surveillance programs*: For workers involved in high-risk operations and for communities likely to be affected by incidents, including mental health services. Evidence from prior major spills shows lasting mental and physical impacts without sustained monitoring and care.

4. *Require publicly available baseline environmental data:* As a condition of approval, allow independent verification and post-project comparisons.
5. *Incentivize prevention-by-design and safer technologies:* Through procurement preferences, insurance discounts, or tax credits for projects that demonstrably reduce risk.

CASE STUDY SNAPSHOT: APPLYING THE ELEMENTS

A hypothetical offshore wind construction project in a sensitive coastal region can be applied as follows:

1. Conduct early habitat mapping and schedule piling outside seasonal bird migration windows (avoidance).
2. Require all contractors to hold ISO 45001 certification and demonstrate a SEMS aligned with the API RP 75 W guidance for renewables.
3. Use prefabricated turbine foundations to minimize offshore activity, schedule heavy lifts in optimal weather windows, and deploy underwater passive acoustic monitoring to detect marine mammals.
4. Maintain a community liaison officer, publish weekly environmental monitoring dashboards, and run quarterly emergency drills with local coastal guards and hospitals.

LESSONS FROM PAST INCIDENTS

The 2010 Deepwater Horizon disaster illustrated the devastating consequences of inadequate safety and environmental safeguards. Beyond the tragic loss of life, the spill caused widespread marine pollution and damaged fisheries, leading to long-term public health effects in coastal communities. These incidents highlight the importance of a transparent preventive system.

MONITORING, EVALUATION AND CONTINUAL IMPROVEMENT

Continuous improvement requires measurements. Key performance indicators (KPIs) should include the lost-time injury frequency, number of spills and volumes, exceedances of environmental limits (e.g., turbidity, hydrocarbon levels), result of emergency drills, and worker health surveillance outcomes. Independent third-party audits and transparent reporting can accelerate learning and build trust.

CONCLUSION

Protecting public health and the environment during offshore construction requires more than compliance checklists; it demands integrated design choices, robust management systems, rigorous contractor governance, continuous monitoring, and meaningful engagement with affected communities. International standards (ISO 45001) and industry SEMS guidance (API RP 75 and its renewables-focused variants) provide practical frameworks. Experience from major incidents demonstrates the human and ecological costs of failure and the value of preparedness. The construction of offshore structures has become the cornerstone of global energy production and maritime development. However, it introduces significant challenges related to worker health and safety as well as environmental sustainability. This study examines integrated strategies for embracing health, safety, and greener practices during offshore construction. Implementing the layered measures outlined here and backing them with regulatory requirements, monitoring, and sustained health surveillance will materially reduce risks and improve outcomes for workers, coastal populations, and marine ecosystems.

The construction of offshore structures is vital for meeting global energy and economic demands. However, this poses risks to worker safety, public health, and marine ecosystems. By embracing health, safety, and greener environmental practices, the offshore industry can prevent accidents, reduce ecological footprint, and build public trust. Integrated HSE management systems, technological innovations, prevention-by-design, and stakeholder engagement form the foundation for sustainable offshore construction. The future of offshore development should harmonize human safety with environmental stewardship to ensure resilience, efficiency, and sustainability. The construction of offshore structures presents significant challenges for worker safety, public health, and environmental sustainability. However, by adopting integrated approaches that prioritize health, enforce safety, and

embrace greener technologies, it is possible to responsibly build offshore infrastructure. A commitment to HSE not only reduces accidents and ecological harm but also enhances social licenses, economic efficiency, and long-term sustainability. The future of offshore development aims to harmonize human safety with environmental stewardship.

Recommendations

To fully embrace health, safety, and greener practices in offshore construction, the following recommendations are proposed.

1. *Mandate integrated HSE management systems*: Regulators require certified HSE management systems (ISO 45001 + ISO 14001) to cover the health, safety, and environment of all offshore projects.
2. *Promote prevention-by-design*: Incentivize engineering solutions that minimize offshore work time and human exposure.
3. *Enhance training and workforce health*: Expand mental health support and implement fatigue management programs.
4. *Adopt Eco-friendly Technologies*: Encourage hybrid-powered construction vessels, recyclable materials, and noise reduction techniques.
5. *Community engagement*: Involve coastal communities in environmental monitoring and publish transparent HSE performance data.
6. *Continuous monitoring and improvement*: Apply lessons from past incidents, use digital technologies, and maintain long-term health and environmental surveillance.
7. *Promoting development and research*: Research on Nigerian-specific HSE and EIA issues should be conducted in cooperation with academic institutions, trade associations, and industry participants. Data-driven solutions and locally relevant strategies can be produced through such studies.
8. *Putting emergency response mechanisms in place*: Effective emergency response measures, such as evacuation plans, fire extinguishers, and first-aid kits, should be installed on construction sites. Employees should conduct regular exercises to guarantee that they are ready for any eventuality.

REFERENCES

1. Fernández-Muñiz B, Montes-Peón JM, Vázquez-Ordás CJ. Integration of safety and environmental management systems: Impacts on organizational performance. *Saf Sci.* 2020;130:104–16.
2. Lichtveld M, Sherchan S, Gam KB, Kwok RK, Mundorf C, Shankar A, Soares L. The Deepwater Horizon oil spill through the lens of human health and the ecosystem. *Curr Environ Health Rep.* 2016;3:370–8. doi:10.1007/s40572-016-0119-7.
3. Roberts C, Marlow P. Occupational health challenges in offshore construction. *Int J Mar Saf.* 2018;52(2):145–59.
4. Thomsen F, Andersson M, Schmidt B. Noise mitigation in offshore wind farm construction: Best practices and emerging technologies. *Renew Energy.* 2020;148:1082–92.
5. Browne J. Managing risks in offshore engineering projects. *Offshore Eng.* 2020;45(3):211–25.
6. American Bureau of Shipping. Guide for Marine Health, Safety, Quality, Environment, and Energy (MHQE) Systems. Houston (TX): American Bureau of Shipping; 2021.
7. American Petroleum Institute. Recommended Practice 75: Safety and Environmental Management Systems for Offshore Operations. Washington (DC): American Petroleum Institute (API); 2019.
8. International Organization for Standardization. ISO 45001:2018—Occupational Health and Safety Management Systems: Requirements with Guidance for Use. Geneva: ISO; 2018.
9. International Maritime Organization (IMO). International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, as modified by the Protocol of 1978 (MARPOL 73/78). London: IMO; 1978. Entered into force 2 Oct 1983. Available from: <https://www.imo.org>
10. Chen Y, Li X, Wang S. Digital twin applications in offshore construction safety and environmental management. *Mar Struct.* 2022;84:102–19.