Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 01 , January - 2026

Effectiveness of the Environmental Management System (EMS) in Ensuring Compliance with Neom Environmental Requirements

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ABSTRACT: - This paper evaluates the effectiveness of the Environmental Management System (EMS) implemented on a major infrastructure project within NEOM and examines how successfully it ensures compliance with NEOM's stringent environmental requirements. The study integrates evidence from EMS documentation, NEOM environmental guidelines, internal audit results, field inspections, and staff interviews to assess the practical performance of the EMS across various operational conditions.

Given NEOM's environmentally sensitive setting characterized by desert ecosystems, wadis, archaeological heritage sites, and diverse flora, fauna and the importance of robust environmental controls cannot be overstated. NEOM's regulatory framework demands systematic planning, operational discipline, proactive risk identification, and continuous environmental protection throughout construction activities.

The research identifies how the EMS translates documented procedures into real field actions and evaluates its effectiveness in managing dust emissions, waste streams, spills, biodiversity protection, and Land Use Permit (LUP) compliance. While the EMS demonstrates strong capability in reducing environmental risks and raising workforce awareness, its overall success is influenced by factors such as subcontractor performance, site supervision, environmental training, and resource availability.

The study concludes that the EMS has been effective in translating documented procedures into practical site-level controls, resulting in improved compliance, reduced environmental risks, and enhanced workforce awareness. Measurable improvements were observed in dust control, waste management, spill prevention, biodiversity protection, and Land Use Permit (LUP) compliance. However, gaps remain in documentation consistency, subcontractor performance, and digital reporting. Addressing these areas through improved digital integration, strengthened subcontractor oversight, and continuous training will further enhance EMS performance and support NEOM's long-term sustainability objectives.

1.INTRODUCTION; -

NEOM represents one of the most ambitious and technologically advanced megaprojects in the world, designed to be a model for sustainable development, innovation, and environmental stewardship. Spanning deserts, mountains, wadis, coastal areas, and archaeologically significant zones, the project integrates cutting edge infrastructure while striving to maintain ecological balance. These diverse landscapes present unique environmental sensitivities and risks, including dust emissions, soil erosion, biodiversity disruption, water scarcity, and potential damage to heritage sites.

Construction operations at NEOM involve large scale excavation, earthworks, heavy machinery movement, and hazardous materials handling. These activities inherently carry environmental risks such as dust and noise pollution, water contamination, waste generation, and disruption of sensitive habitats. In response, NEOM enforces a strict regulatory framework supported by the Environmental Management System (EMS), which establishes processes for identifying environmental aspects, assessing potential impacts, implementing operational controls, and monitoring compliance.

While EMS frameworks provide a structured approach, their effectiveness depends on practical implementation. Construction sites are dynamic, with changing work zones, variable manpower, subcontractor involvement, and fluctuating environmental conditions such as dust storms or sudden rainfall. Ensuring compliance under such circumstances requires a robust EMS supported by trained personnel, continuous monitoring, and prompt corrective actions.

This study evaluates the effectiveness of the EMS on a major NEOM construction project, emphasizing its operational impact on environmental compliance. It assesses system strengths, identifies gaps, and provides practical recommendations for enhancing EMS performance, ensuring that environmental management is not only theoretical but also operationally effective.

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2.OBJECTIVES; -

The objectives of this study are

1.Evaluate EMS Structure and Implementation: - Examine the design of the project EMS and its alignment with NEOM guidelines and ISO 14001 2015 standards, focusing on operational application.
2.Assess EMS Effectiveness in Environmental Compliance: - Analyze how effectively the EMS ensures compliance with environmental requirements, particularly in dust control, waste management, spill response, biodiversity protection, and Land Use Permit (LUP) adherence.
3.Identify Strengths and Weaknesses: - Determine operational strengths, gaps, and weaknesses influencing EMS performance in real-world conditions.
4.Provide Practical Recommendations: - Recommend actionable improvements in training, monitoring, documentation, and subcontractor management.
5.Measure Corrective Action Impact: - Evaluate EMS driven corrective actions through audits, monitoring trends, and case studies, assessing their effectiveness in achieving compliance.

Through these objectives, the study provides a holistic evaluation of EMS effectiveness, ensuring that environmental management practices are operationally robust and aligned with NEOM's sustainability vision.

3.METHODOLOGY: -

This study adopted a mixed-methods research approach to systematically evaluate the effectiveness of the Environmental Management System (EMS) in ensuring compliance with NEOM environmental requirements. The methodology was designed to ensure validity, reliability, and replicability by integrating quantitative performance data with qualitative insights derived from structured field observations, internal audits, and staff interviews. The approach aligns with ISO 14001:2015 requirements, particularly clauses related to performance evaluation, monitoring, and continual improvement.

3.1 RESEARCH DESIGN: -

A convergent mixed-methods design was employed; whereby qualitative and quantitative data were collected in parallel and analyzed collectively to provide a robust and evidence-based assessment of EMS effectiveness. Quantitative data were obtained from audit records, inspection reports, and environmental monitoring logs, while qualitative data were derived from staff interviews and field observations. This design minimized reliance on anecdotal evidence and enabled triangulation across multiple data sources.

3.2 EMS DOCUMENT REVIEW: -

A systematic review of EMS-related documentation was conducted to assess alignment with NEOM requirements and ISO 14001:2015. Documents reviewed included

1.Project EMS Manual and procedures
2.Environmental Aspects and Impacts Register
3.Legal and Other Requirements Register
4.Training matrices and competency records
5.Environmental monitoring plans and reports
6.Corrective and Preventive Action (CAPA) logs

This review established the baseline EMS framework, control measures, and compliance obligations against which field performance was evaluated.

3.3 FIELD OBSERVATIONS: -

Structured field observations were carried out through multiple site visits over different operational periods (morning, midday, and evening) to capture variations in construction activity and environmental conditions. Observations focused on

1.Dust and air quality conditions
2.Waste management practices
3.Water consumption and housekeeping

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4.Heavy equipment movement and site layout
5.Fuel, oil, and chemical handling
6.Housekeeping and material storage
7.Compliance with Land Use Permit (LUP) boundaries
8.Protection of sensitive receptors, including wadis, biodiversity zones, and heritage areas
9.Fauna and flora

All EMS practices were compared against NEOM regulations (PRC-711, PRC-712, PRC-715) and international standards such as ISO 14001:2015 to assess both documented procedures and field application.

3.4 INTERNAL AUDIT AND INSPECTION ANALYSIS: -

Environmental audit records, Non-Conformance Reports (NCRs), Improvement Notices (IP), Prohibition Notices (PN), Stop Work Notices, Corrective and Preventive Action (CAPA) logs, weekly inspection reports, and monthly environmental summaries were analyzed. The analysis focused on identifying trends in noncompliance, evaluating the timeliness and effectiveness of corrective actions, and assessing overall adherence to EMS procedures

1.Frequency and nature of nonconformities
2.Timeliness and effectiveness of corrective actions
3.Trends in environmental compliance performance
4.Documentation consistency and reporting efficiency

Baseline data were derived from audit findings during the initial project mobilization phase, while performance improvements were evaluated over a 12–15-month operational period following implementation of enhanced controls. Trend analysis was used to assess EMS effectiveness over time.

3.5 STAFF INTERVIEWS: -

A purposive sample of skilled personnel from different departments was selected for the interview process. Semi-structured interviews were conducted with approximately 25–30 personnel, representing key functional roles involved in environmental management and site operations. Interviewees included environmental officers, site supervisors, safety officers, equipment operators, and subcontractor representatives. Purposeful sampling was adopted to ensure balanced representation from both supervisory and operational levels, in line with ISO 14001:2015 requirements for competence, awareness, and participation, thereby capturing diverse perspectives on EMS implementation.

The interviews focused on awareness of EMS requirements, practical implementation challenges, subcontractor compliance, training effectiveness, and opportunities for operational improvement. Qualitative data obtained from the interviews were analyzed using thematic analysis, enabling the identification of recurring patterns related to workforce behavior, compliance barriers, and overall system effectiveness. This structured and systematic approach ensured that the findings were based on documented evidence rather than isolated observations, thereby strengthening the credibility, validity, and reliability of the qualitative results.

3.6 QUALITATIVE DATA ANALYSIS: -

Qualitative data from interviews were analyzed using thematic analysis, following a structured process of data familiarization, coding, theme development, and interpretation. Recurring themes related to workforce behavior, compliance barriers, subcontractor variability, and system effectiveness were identified and cross-validated against audit findings and field observations. This analytical approach enhanced the credibility, dependability, and confirmability of the qualitative findings.

3.7 COMPLIANCE BENCHMARKING: -

EMS practices were evaluated against

1.NEOM PRC-711(Environmental Protection)
2.NEOM PRC-712: (Monitoring and Reporting)
3.NEOM PRC-715: (Waste Management)
4.ISO 14001:2015: (Environmental Management Systems)
5.Project specific EMS manual

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6.CESMP
7.ESIA
8.Ecological Survey Report
9.Pre Mobilization Report

Benchmarking allowed identification of system strengths, operational gaps, and areas for improvement relative to best practices.

3.8 METHODOLOGICAL RIGOR AND LIMITATIONS: -

The integration of multiple data sources ensured triangulation and reduced bias. Standardized tools, defined sampling strategies, and systematic analysis methods support the replicability of the study in similar construction environments. While findings are context-specific to a NEOM infrastructure project, the methodological framework is transferable to other megaprojects with comparable environmental management challenges.

4.EMS FRAMEWORK OVERVIEW: -

4.1 ENVIRONMENTAL POLICY: -

The environmental policy serves as the foundation of the EMS, declaring the project's commitment to compliance, pollution prevention, biodiversity protection, and continuous improvement. It establishes clear expectations for environmental performance and ensures all personnel understand their responsibilities.

The policy is supported by internal and external factors, including regulatory requirements, subcontractor awareness, resource availability, and environmental conditions, which collectively shape EMS implementation.

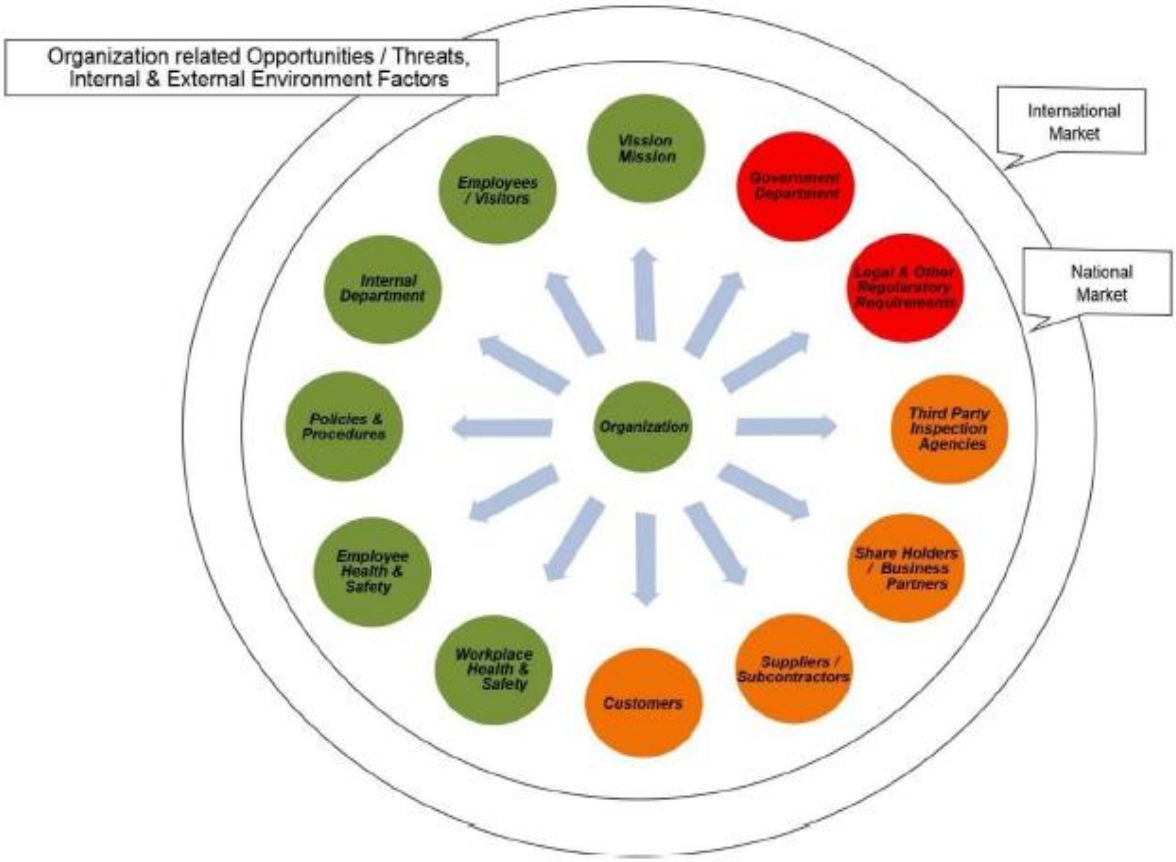

Figure 1. Influence of Internal and External Environmental Factors on EMS Implementation
Illustrates how organizational policies, workforce awareness, legal requirements, subcontractor practices, and stakeholder expectations interact to shape environmental management.

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4.2 ENVIRONMENTAL ASPECTS AND IMPACTS: -

Identifying and evaluating environmental aspects is essential for determining potential impacts and implementing appropriate controls. The project uses an Aspects and Impacts Register that evaluates likelihood, severity, and significance.

MAJOR ENVIRONMENTAL ASPECTS IDENTIFIED: -

1.Dust emissions arising from excavation works, earthmoving activities, vehicle movement, and material stockpiling
2.Air emissions generated by diesel-powered generators, construction machinery, and transportation vehicles
3.Noise pollution associated with heavy equipment operation and continuous construction activities
4.Waste generation, including both hazardous and non-hazardous waste streams from construction and support activities
5.Fuel, oil, and chemical spills related to storage, refueling, and maintenance operations
6.Soil erosion and land degradation resulting from excavation, grading, and exposure of bare ground, particularly during wind and rainfall events
7.Biodiversity disturbance, including potential impacts on native flora and fauna and sensitive habitats
8.Archaeological and cultural heritage impacts due to construction activities in proximity to protected or heritage-sensitive areas
9.Water consumption and wastewater management, including potable water use, construction water demand, and wastewater discharge
10.Energy consumption is associated with site operations, temporary facilities, and construction equipment.

These aspects were evaluated based on likelihood, severity, and environmental sensitivity, allowing prioritization of controls and mitigation measures. The identified aspects align with ISO 14001:2015 principles of lifecycle thinking, risk-based planning, and continuous improvement, and are consistent with findings reported in peer-reviewed studies on EMS implementation in megaproject and infrastructure developments.

4.3 LEGAL AND OTHER REQUIREMENTS: -

The project maintains a detailed Legal Register incorporating NEOM environmental guidelines and ISO 14001 requirements. Compliance obligations include.

1.LUP restrictions
2.Waste disposal protocols
3.Dust and noise limits
4.Sensitive receptor protection
5.Spill reporting procedures

Regular updates ensure that staff remain aware of any changes in regulatory requirements.

4.4 OPERATIONAL CONTROLS: -

Operational controls form the core of EMS implementation. Key controls include

1.Waste Management: - Proper segregation, labeling, storage, transportation, and disposal.
2.Dust Suppression: - Water spraying, covering stockpiles, enforcing speed limits.
3.Hazardous Storage: - Secondary containment, labeling, restricted access.
4.Spill Prevention and Response: Availability of spill kits, trained responders, emergency protocols.
5.Noise Control: Restricting noisy activities, maintaining equipment, providing barriers.
6.LUP Compliance: Ensuring no activities encroach on restricted or sensitive zones.

The effectiveness of these controls strengthens environmental performance but requires constant supervision. especially during peak construction periods.

4.5 COMPETENCE, TRAINING, AND AWARENESS: -

Training programs include.

1.EMS induction
2.Waste management procedures

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3.Spill response
4.Biodiversity protection
5.LUP compliance
6.Emergency preparedness

A structured training matrix tracks staff competency, refresher requirements, and participation levels. Toolbox talks provide real-time reinforcement of critical awareness topics.

4.6 EMERGENCY PREPAREDNESS AND RESPONSE: -

The project maintains an emergency response plan supported by.

1.Spill kits placed at strategic points
2.Firefighting equipment
3.Trained responders
4.Regular emergency drills
5.Clear communication channels

These measures ensure readiness to respond to environmental emergencies such as fuel spills, fires, or chemical leaks.

4.7 MONITORING AND MEASUREMENT: -

Environmental monitoring covers

1.Dust concentration
2.Noise levels
3.Water usage
4.Fuel consumption
5.Waste generation
6.Spills
7.Compliance with LUP boundaries
8.Biodiversity and archaeological protection

Data is analyzed and compiled in routine reports submitted to NEOM.

4.8 INTERNAL AUDITS AND CORRECTIVE ACTIONS: -

Internal audits evaluate compliance with EMS requirements and NEOM guidelines. Audit findings generate corrective actions that must be addressed within specified timelines. The process helps identify weaknesses and drive continuous improvement.

4.9 CONTINUOUS IMPROVEMENT AND EMS CYCLE: -

The EMS follows the PDCA cycle

1.Plan: Identify aspects, legal requirements, controls
2.Do: Implement operational controls and training
3.Check: Monitor performance and conduct audits
4.Act: Implement corrective actions and improve procedures

This cycle sustains long-term enhancements in environmental performance.

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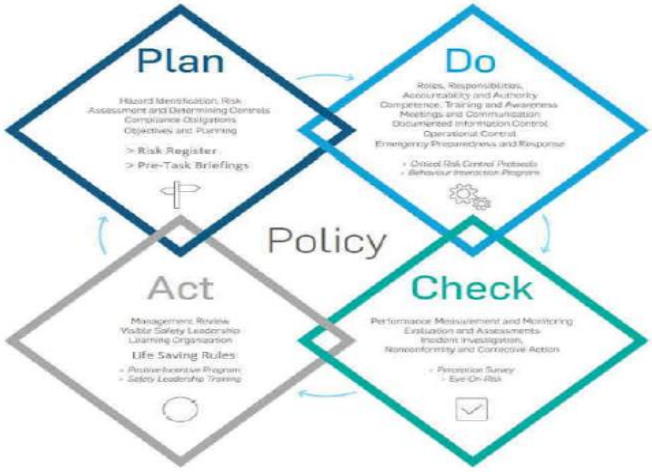

Figure 2. EMS Implementation Cycle

Continuous improvement cycle: Policy & Planning → Aspects & Impacts → Operational Controls → Training → Monitoring → Audits → Corrective Actions → back to Policy.

5.RESULTS AND ANALYSIS: -

5.1 COMPLIANCE IMPROVEMENT: -

Analysis of field observations, internal audit records, and environmental monitoring data indicates a substantial improvement in compliance with NEOM environmental requirements following the implementation of the Environmental Management System (EMS). Baseline performance data were derived from audit findings, inspection reports, and environmental incident records collected during the initial project mobilization phase, prior to full EMS implementation. Subsequent performance improvements were assessed over a 12–15-month operational period following the introduction of enhanced operational controls, workforce training, and corrective action closure. Key achievements include

1.Waste Management: - Implementation of strict segregation protocols and controlled disposal processes has resulted in a measurable reduction in environmental contamination. For instance, solid waste is separated into recyclable, non-recyclable, and hazardous categories, each with designated storage areas and disposal schedules. Hazardous waste incidents have declined by over 30% compared to initial project phases.
2.Dust Control: - Water spraying schedules were intensified, vehicle speeds on-site were reduced, and stockpiles were fully covered. These measures have significantly minimized dust generation, particularly during high wind conditions. Dust deposition monitoring at sensitive receptors indicated reductions of 30–40% after implementing these measures.
3.Hazardous Materials Handling: - Compliance with chemical storage and spill response protocols has improved. Secondary containment systems, bunding, and emergency response drills have strengthened risk management.
4.During the first three months following project mobilization, three Land Use Permit (LUP) violations were recorded, primarily due to limited site familiarity with approved boundaries. Following this period, strict enforcement of LUP requirements played a critical role in protecting ecologically sensitive areas, including wadis, biodiversity zones, and heritage sites. Routine inspections consistently confirmed adherence to approved LUP boundaries, and any minor deviations were immediately addressed through corrective actions and reinforced supervision. To further enhance boundary control, sand berms were installed, green flags were positioned, and entry/exit points were monitored by site security systems, significantly improving boundary visibility and compliance. Subsequent monitoring confirmed zero LUP-related observations, demonstrating the effectiveness of these control measures.
5.Monitoring and Reporting: Frequent monitoring of water consumption, energy use, dust, noise, and waste generation has created a reliable database for environmental performance evaluation. Early detection of potential issues allowed for immediate mitigation.

Overall, the results demonstrate that the EMS effectively translated documented policies and procedures into consistent field-level controls, resulting in measurable improvements in environmental performance. The observed reductions in incidents, improved monitoring outcomes, and enhanced compliance consistency confirm the EMS's effectiveness as a practical tool for managing

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environmental risks within complex and dynamic NEOM construction environments.

5.2 ENVIRONMENTAL RISK REDUCTION: -

Consistent implementation of operational controls helped

1.Dust Emissions: - Reduced through a combination of water spraying, vehicle speed management, and real-time monitoring, minimizing both worker exposure and environmental impact.
2.Waste Contamination: - Enhanced segregation and disposal protocols limit the potential for soil and water contamination.
3.Spill Incidents: - A clear spill response plan, regular drills, and rapid response protocols have reduced chemical and fuel spill occurrences.
4.Biodiversity Protection: - Proactive habitat monitoring, seasonal restrictions on construction activities, and protection of flora and fauna have mitigated potential ecological disturbances.
5.Health and Safety Risks: - Clean and organized worksites reduce the likelihood of accidents, ensuring both environmental and human safety.

5.3 STAFF AWARENESS AND BEHAVIOR CHANGE: -

Regular training and toolbox talk improved worker understanding of environmental responsibilities. This has positively influenced site cleanliness, waste segregation, and spill reporting.

A trained and engaged workforce is critical to EMS success. Observations indicate:

1.Workers actively report environmental issues, demonstrating understanding of operational controls.
2.Toolbox talks, daily briefings, and refresher training reinforce environmental awareness.
3.Supervisors play a key role in maintaining adherence to EMS procedures and fostering a culture of responsibility.

5.4 MONITORING EFFICIENCY: -

Enhanced monitoring and timely corrective actions have helped prevent incidents from escalating into serious environmental impacts.

Monitoring systems and inspection protocols allow for continuous assessment

1.Dust and noise levels are tracked against NEOM environmental thresholds.
2.Waste segregation and disposal are audited weekly.
3.Water consumption trends are analyzed to identify inefficiencies.
4.Early detection of minor spills prevents escalation into major incidents.

Data-driven monitoring enhances both compliance and operational decision-making.

5.5 AREAS FOR IMPROVEMENT: -

Despite strong performance, the study identified several areas needing attention

1.Documentation Gaps: - Manual reporting systems sometimes lead to delayed or inconsistent data. Digital integration could improve accuracy and accessibility.
2.Subcontractor Compliance: - Variation in subcontractor adherence to EMS requirements highlights the need for improved oversight and training.
3.High Wind Conditions: - Occasional lapses in dust suppression during extreme weather require contingency plans and adaptive measures.
4.Knowledge Retention: - Continuous training and refresher sessions are necessary to maintain high levels of workforce awareness, particularly for transient staff.

5.6 SUSTAINABILITY INTEGRATION: -

Beyond compliance, the EMS contributes to NEOM's long-term sustainability objectives. By embedding environmental

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considerations into daily operations, the system ensures that resource efficiency and ecological preservation are integral to project planning. Water recycling initiatives reduce freshwater consumption, while energy-efficient machinery minimizes greenhouse gas emissions, demonstrating that EMS implementation actively supports NEOM's sustainability vision.

Environmental considerations are integrated into procurement decisions sourcing low impact materials and selecting contractors with strong sustainability records—reinforcing a culture of responsible construction. This holistic approach ensures environmental management is considered at every stage, from planning through execution, enhancing operational efficiency and ecological stewardship.

6.CASE EXAMPLES: -

6.1 DUST MANAGEMENT: -

During early site phases, dust from excavation and stockpiles frequently exceeded safe levels. Implementation of a comprehensive dust control program, including water spraying, speed limits, and stockpile covers, reduced particulate matter by 35% within three months. Monitoring points near sensitive receptors, including residential and ecological areas, confirmed sustained compliance with NEOM air quality standards.

6.2 WASTE SEGREGATION AND DISPOSAL: -

Initial audits identified inconsistent waste segregation and improper disposal of hazardous materials. By establishing clearly labeled storage zones, conducting staff training, and scheduling frequent waste collection, the project achieved full compliance within six months. Hazardous waste incidents dropped from an average of 4 per month to fewer than 1 per month.

6.3 SPILL RESPONSE: -

A minor fuel spill during vehicle refueling highlighted the need for rapid response protocols. Emergency drills, containment materials, and clear reporting procedures enabled immediate containment, preventing environmental damage. Follow-up audits verified correct execution and reinforced staff preparedness.

6.4 BIODIVERSITY PROTECTION: -

Construction activities near wadis risked disturbing native flora and fauna. EMS measures included restricted working hours during sensitive periods, habitat fencing, and species monitoring. Post-construction surveys indicated no significant disruption to local biodiversity, demonstrating the effectiveness of mitigation measures.

6.5 TECHNOLOGY-DRIVEN COMPLIANCE: -

Real-time monitoring systems, IoT sensors, automated reporting, GPS-enabled waste tracking, and dashboards enabled instant detection of deviations, predictive analysis, and proactive mitigation. Technology has improved operational efficiency and compliance transparency.

7.DISCUSSION: -

This study demonstrates that the Environmental Management System (EMS) implemented on the NEOM infrastructure project is largely effective in translating regulatory requirements and documented procedures into measurable environmental performance improvements. Evidence drawn from field observations, internal audits, monitoring data, and structured staff interviews confirms that the EMS has strengthened compliance across key environmental aspects, including dust control, waste management, spill prevention, biodiversity protection, soil erosion control, and Land Use Permit (LUP) adherence.

The EMS demonstrates strong capability in managing environmental aspects and ensuring compliance with NEOM's high standards. However, its success depends largely on

1.Human behavior
2.Continuous supervision
3.Team coordination
4.Subcontractor commitment

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5.Consistent record-keeping

7.1 LINKING EMS PERFORMANCE TO METHODOLOGICAL EVIDENCE: -

Audit trend analysis indicates a clear reduction in non-conformances following the initial project mobilization phase. Baseline audit records from the first three months identified recurring issues related to dust emissions, improper waste segregation, and occasional LUP boundary deviations. However, audit data collected over the subsequent 12–15-month operational period showed a consistent decline in repeat findings, particularly in hazardous waste handling (over 30% reduction in incidents) and dust exceedances at sensitive receptors (30–40% reduction). These improvements correlate directly with strengthened operational controls, enhanced supervision, and targeted corrective actions identified through the EMS audit cycle.

Staff interviews further support these findings. Thematic analysis revealed recurring interview themes related to improved awareness of EMS requirements, increased confidence in spill response procedures, and better understanding of LUP restrictions among supervisory staff. These insights validate that EMS effectiveness is not solely procedural but is also driven by behavioral change and workforce engagement, consistent with ISO 14001's emphasis on competence, awareness, and leadership.

7.2 SUBCONTRACTOR VARIABILITY AS A KEY CHALLENGE: -

Despite overall improvements, subcontractor performance variability emerged as a persistent challenge. Audit records and inspection reports frequently associated minor non-conformances with subcontractor-led activities, particularly during high-intensity construction phases. Interview responses echoed this pattern, with environmental officers and supervisors highlighting inconsistent understanding of EMS requirements among subcontractor personnel and high workforce turnover as contributing factors.

This evidence underscores the need for stronger subcontractor integration into the EMS framework, including standardized induction programs, targeted refresher training, and clearer contractual environmental obligations. Without consistent subcontractor alignment, the effectiveness of EMS controls may be diluted, particularly in large-scale, multi-contractor environments such as NEOM.

7.3 DIGITAL INTEGRATION AND DOCUMENTATION EFFICIENCY: -

Another challenge identified through both audits and interviews relate to documentation consistency and reporting efficiency. Manual reporting systems were found to contribute to delays in data consolidation, inconsistencies in inspection records, and limited real-time visibility of environmental performance trends. These findings aligned with interview themes emphasizing the administrative burden on environmental staff and the difficulty of tracking corrective actions across multiple work fronts.

The evidence strongly supports the adoption of digital EMS platforms, including mobile inspection tools, automated corrective action tracking, and real-time monitoring dashboards. Such systems would enhance data accuracy, improve traceability, and support proactive environmental management key elements of continuous improvement under ISO 14001.

7.4ADAPTIVE MANAGEMENT UNDER DYNAMIC ENVIRONMENTAL CONDITIONS: -

NEOM's environmental context is characterized by high winds, extreme temperatures, wadis, sensitive biodiversity zones, and archaeological areas require adaptive management. Field observations confirmed that environmental risks fluctuate rapidly due to weather and operational changes. The EMS proved most effective when supported by proactive supervision, contingency planning, and flexible operational controls, such as intensified dust suppression during wind events and temporary work restrictions near sensitive receptors.

This finding highlights that EMS effectiveness in megaprojects depends not only on system design but also on responsiveness to site-specific environmental conditions, reinforcing the importance of continuous monitoring and dynamic risk assessment.

8.CONCLUSION: -

This study concludes that the Environmental Management System implemented on the NEOM infrastructure project is effective in supporting environmental compliance and reducing construction-related environmental risks. The EMS has demonstrably improved performance in critical areas such as dust control, waste management, spill response, soil erosion prevention, biodiversity protection, and Land Use Permit compliance, as evidenced by audit trends, monitoring data, and workforce feedback.

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The primary contribution of the EMS lies in its ability to convert regulatory requirements and policy commitments into practical, field-level controls supported by monitoring, training, and corrective action mechanisms. Measurable reductions in environmental incidents and improved workforce awareness confirm the system's operational value within NEOM's highly sensitive environmental setting.

However, the study also identifies strategic areas requiring continued attention to sustain and enhance EMS effectiveness. These include strengthening subcontractor environmental governance, improving documentation accuracy through digital integration, and further embedding adaptive management practices to respond to NEOM's dynamic environmental conditions.

From a broader perspective, the findings demonstrate that a well-implemented EMS, aligned with ISO 14001 and tailored to project-specific risks, can play a critical role in achieving compliance and supporting sustainable construction in megaprojects. For NEOM, continued investment in digital tools, workforce capability, and subcontractor alignment will be essential to maintaining high environmental standards and realizing its long-term sustainability vision.

9.RECOMMENDATIONS: -

To strengthen EMS performance and align with NEOM's sustainability goals, the following recommendations are proposed.

1.Digital Platform Adoption: - Introduce real-time digital monitoring systems for inspections, reporting, and analytics. Mobile apps and dashboards can improve accessibility, accuracy, and speed of data collection.
2.Enhanced Subcontractor Oversight: - Implement standardized training, monitoring schedules, and contractual compliance requirements to ensure all subcontractors adhere to EMS protocols.
3.Increased Training Frequency: - Conduct regular refresher sessions, toolbox talks, and scenario-based drills to maintain workforce competency and engagement.
4.Advanced Monitoring Systems: - Utilize continuous environmental monitoring for dust, noise, water, and waste. Predictive analytics can identify risks before they escalate.
5.KPI Implementation: - Develop measurable KPIs for compliance, operational performance, and environmental outcomes. KPIs can include dust levels, waste segregation rates, spill response times, and training completion percentages.
6.Interdepartmental Coordination: - Foster effective communication between environmental teams, project departments, and contractors to facilitate coordinated decision-making.
7.Visual and Multilingual Guidance: - Deploy clear signage, charts, and guidance in multiple languages to ensure understanding among a diverse workforce.
8.Joint Inspections: -Conduct collaborative inspections with site teams, environmental officers, and subcontractors to ensure shared responsibility and accountability.
9.Continuous Improvement Reviews: - Schedule periodic EMS reviews incorporating audit findings, lessons learned, and technological advancements to refine processes and controls.

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11.APPENDIX A: - INTERESTED PARTIES AND EXPECTATIONS

INTERESTED PARTIES	NEEDS AND EXPECTATIONS
Clients and parties working on behalf of the client (e.g. project management teams)	Conformance with the environmental requirements of the Contract
Engineering design consultants	Compliance with Client's environmental standards and national regulations
Environmental regulatory authorities (e.g., GAMEP, MEWA, NCEC etc.)	Compliance with regulations, national laws, permits
Contractors/Subcontractors	Clear EMS procedures, environmental training, incident response
Site Workers	Awareness of environmental risks, training, PPE
Local Communities	Dust/noise control, spill prevention, access
Environmental Team (AICC)	Resources, authority, documented roles
Emergency Services	Access to ERP, coordination during incidents

APPENDIX B: - KEY ENVIRONMENTAL ASPECTS AND MITIGATION MEASURES

Environmental Aspect	Potential Impact	Mitigation Measures	Monitoring Frequency
Dust emissions	Air quality, respiratory risks	Water spraying, stockpile covering, vehicle speed control	Daily
Noise	Disturbance to fauna and communities	Noise barriers, restricted hours	Daily
Waste generation	Soil contamination	Segregation, recycling, proper disposal	Daily
Hazardous materials	Spills, contamination	Secure storage, labeling, emergency response	Weekly
Water consumption	Resource depletion	Efficient use, recycling, monitoring	Weekly
Flora & fauna	Habitat disturbance	Fencing, careful excavation, monitoring	Biweekly
Archaeological sites	Cultural damage	Land Use Permits, supervision	Monthly