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# Environmental Health and Safety Performance Optimization in Mega Construction and Urban Development Projects

MUHAMMAD ARSLAN ANWAR BHUTTA

***Abstract- Mega constructions and urban development initiatives in the Kingdom of Saudi Arabia are increasing the scope and pace of built-environment delivery, alongside raising the technological complexities involved in achieving the objectives of such ventures. This review explores how environmental, health and safety (EHS) performance can be improved in giga and mega projects through integrating risk management, digital technologies, health safety and worker engagement, environment management and emergency preparedness measures. This paper adopts a rapid review approach similar to the one outlined in the Springer template below; the research approach revolves around trends, challenges, pragmatic trade-offs and possible futures rather than focusing exclusively on a particular case study. Literature between 2020 and 2025 is analyzed based on topics including the risks of construction under Saudi Vision 2030, high-rise building hazards and risks, occupational safety regulations, digital safety technologies, exposure to climate risks, circular construction and project level performance indicators. The findings indicate that best EHS performance is achieved when regulatory programs are turned into learning systems that utilize leading indicators, advanced planning with the help of BIM technology, IoT-based monitoring of the project site, employee participation and emergency response drills. Major impediments in terms of performance improvement include interface problems between contractors, linguistic diversity of the workforce, heat stress, problems related to temporary structures, poor data integration, and environmental challenges related to dust pollution, waste disposal, energy consumption and water demands. An optimal EHS model for mega Saudi projects is provided at the end of the review.***

## I. INTRODUCTION

The construction industry in Saudi Arabia is currently experiencing huge transformations owing to various factors such as Vision 2030, urbanization, tourism, logistics improvement and construction of unprecedented mega projects. There have emerged many constructions involving new urban developments, routes of transportation infrastructure, high-rise buildings, industrial centers, and landscape works. These developments present both risks and opportunities. The attached Springer publication concerning mega tall buildings proves that urban projects nowadays are much more complicated than merely constructing a building since they include financial risks, structural engineering complexity, fire safety, energy efficiency, maintenance, and corporate responsibility issues (Konar, 2025). An approach of this kind is highly applicable in case of EHS optimization because the environmental, health, and safety risks related to construction of mega projects do not occur independently but result from interaction between multiple design considerations, contractors' cooperation, weather effects, logistics congestion, temporary works, human fatigue, emergency preparations, and governance problems. Traditionally, the performance regarding environmental, health, and safety issues has been viewed as a compliance activity employing leading indicators including injuries, notices, spills, accidents, occurrences, and similar events. In the context of megaprojects delivery in Saudi Arabia, the mentioned view has several limitations. First, any megaproject includes a large number of workers and migrant workers who work under harsh climatic conditions, carry out heavy lifting and handling, operate in confined areas, perform energizing activities, and work with roads, mobile machines, and fast-growing sites. Second, urban development projects pose many environmental hazards including air pollution caused by dust generation and noise, waste generation, use of groundwater, carbon emissions, and construction-related traffic. According to the results of recent studies, the construction industry ranks among the riskiest industries while digital solutions can prevent the identified dangers

(Daniel et al., 2025; Dodoo et al., 2024; Zhang et al., 2025). In addition, the regulatory bodies in Saudi Arabia are shifting towards giving special attention to EHS issues as a part of their activities. For instance, the Ministry of Human Resources and Social Development requires employers to provide the necessary facilities concerning occupational safety and health in accordance with their operations while such organizations as the National Center for Occupational Safety & Health focus on prevention and awareness of safety risks (MHRSD, 2020; NCOSH, 2024). Such a trend emerges due to the need of achieving the objectives outlined by the Saudi government in the context of Vision 2030 including improvement of quality of life and investments and creating sustainable cities (Vision 2030, 2025). Still, the regulation is different from performance since the former implies the latter.

Therefore, the purpose of the current paper is the investigation of environmental, health, and safety optimization in megaprojects and urban development works in Saudi Arabia. Namely, it considers the ways of optimizing EHS performance during megaproject construction and urbanization works. Contrary to traditional perceptions, EHS performance can be regarded within the framework of EHS strategy rather than safety practices. Thus, this review will analyze four dimensions of EHS optimization. First, it will consider EHS risk management in the planning and design stage. Second, it will investigate the issues of workers' health including those connected with working under hot climate, stress, fatigue, and cultural aspects. Third, it will explore the environmental factors including dust pollution, waste, carbon dioxide, water use, and biodiversity preservation. Fourth, it will discuss the problem of disaster prevention.

## II. AIM, OBJECTIVES AND RESEARCH QUESTIONS

The purpose of this literature review is to systematically construct knowledge on EHS performance optimization in mega construction and urban development in Saudi Arabia. The nature of the proposed study is a review paper, because the subject involves the combination of evidence related to occupational safety, project management, digital construction, environmental management, emergency response and Saudi regulatory transformation.

First, the objective is to identify the most significant types of EHS risk in mega-project implementation, including high-risk processes, hazardous exposures, adverse environmental impacts and emergency situations. Second, it is necessary to assess how the use of new digital solutions such as BIM, IoT, drones, wearable devices, analytics and digital twin technology may move EHS management from compliance to prediction. Third, there is a need to consider the most relevant indicators and best practices in performance measurement for clients, consultants, contractors and sub-contractors in the period between 2020 and 2025. Fourth, it is important to suggest an EHS optimization framework for Saudi Arabia, aligned with the vision 2030 sustainability agenda. Three questions will be addressed in the process of review. What are the most important types of EHS risks, impacting performance in mega-construction projects in Saudi Arabia? Which of the environmental, governance and digital practices are most suitable for improving EHS performance between 2020 and 2025? How can construction organizations combine safety management, environmental management and emergency planning in one performance cycle?

## III. METHODOLOGY

In order to address a complex built-environment topic using the evidence-mapping technique, the structure of the current study adheres to the methodology outlined in the attached Springer paper. As noted by Konar (2025), a thorough literature review, a trend analysis, an examination of challenges, and a discussion of prospects are needed to analyze any complex built-environment problem (Konar, 2025). Given that the optimization of EHS in Saudi mega projects involves various disciplines, a meta-analysis was inappropriate here. An evidence-mapping methodology has been used to identify the key themes, patterns and mechanisms discussed in the previous literature. English-language materials published between 2020 and 2025 have been chosen for this paper. Both Saudi and international databases

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have been searched, including the peer-reviewed scientific journals, industry reports, and review articles. The following keywords have been selected: construction safety, environmental health and safety, Saudi Arabia, mega projects, urban development, BIM, IoT, digital safety, emergency preparedness, heat stress, sustainable construction, circular economy, occupational health, leading indicators, and risk governance. All the sources should relate to at least one of the four topics listed below: occupational health and safety; environmental performance; the use of digital technology; emergency preparedness in mega projects. Opinion pieces unrelated to construction works have been excluded. Data extraction involved reviewing sources in accordance with the coding matrix. Various risk categories, performance indicators, optimization levers, Saudi relevance and potential implementation barriers have been identified for each source. For instance, wearable technologies have been coded depending on their application to health monitoring, real-time intervention, and data governance. Sources discussing BIM and digital twins have been coded in line with their role in design-for-safety, clash avoidance, method planning, and emergency simulations. Materials analyzing sustainable construction have been coded based on waste minimization, carbon footprint reduction, water management and environmental compliance. Thus, a coding matrix was developed for comparing technical controls and organizational policies within the context of EHS optimization.

The synthesis of evidence involved both deductive and inductive methods. The first approach implied the analysis of evidence in accordance with the eight categories related to EHS optimization. Namely, these are: leadership, worker engagement, hazard identification, risk control, competence, emergency preparedness, monitoring, and continual improvement. However, new themes have been introduced in the context of emerging patterns associated with modern construction projects. They include: digital interoperability, heat stress governance, interface-related risks, near-misses quality management, multilingual communication, and environmental data visualization. In other words, the purpose of the paper is to provide a framework applicable to Saudi mega constructions. The source triangulation was employed to ensure the accuracy of findings. Official sources have been included to provide the background for Saudi development as per regulatory and Vision 2030 documents. Peer-reviewed sources have been used for technical and managerial evidence. Following the structural and stylistic features of the attached Springer paper (Konar, 2025), the current paper focuses on trends, barriers, trade-offs and prospects associated with infrastructure development in Saudi Arabia. One limitation of this methodology is the confidential nature of EHS data for Saudi mega projects.

Table 1. Review coding matrix for EHS optimization in Saudi mega construction projects

| Review theme | Main indicators | Data sources | Saudi mega-project application | Optimization lever |
|---|---|---|---|---|
| Worker safety | High-risk permits, serious potential incidents, near-miss quality | Safety reports, inspections, observation data | Cranes, lifting, work at height, temporary works and traffic interfaces | Risk-based assurance and supervisor field coaching |
| Occupational health | Heat exposure, fatigue, stress, medical cases | Weather records, clinic data, wearable alerts | Outdoor work in hot climate and multilingual labour camps | Work-rest cycles, acclimatization and health surveillance |
| Environmental control | Dust, noise, waste, water use, carbon intensity | Monitoring stations, waste manifests, | Urban districts, coastal works, desert logistics and public | Dashboards, circular procurement and mitigation planning |

| | | | | |
|---|---|---|---|---|
| | | material data | interfaces | |
| Emergency readiness | Drill maturity, response time, rescue access, interoperability | Drill reports, scenario tests, command logs | Fire, flood, collapse, road incidents and mass casualty potential | Integrated command, multilingual alerts and authority coordination |

## IV. LITERATURE REVIEW AND THEMATIC SYNTHESIS

From the literature, it is clear that the measurement of EHS performance on construction projects is moving increasingly towards systems capabilities rather than mere document preparation. High performing projects rely on well-defined expectations from leaders, early hazard identification, competent supervision, workers' involvement, reporting and learning. From literature on safety proactivity on Saudi construction projects, the key focus has been measurement of safety culture, management commitment and workers' perception rather than responding to accidents (Alqahtani et al., 2023). Moreover, digital construction safety review demonstrates that technologies are helpful for hazard visibility, although the technology has to be integrated with decision making (Daniel et al., 2025; Zhang et al., 2025).

First, one thematic area concerns occupational safety hazards. Construction projects often involve performance of a number of tasks within a confined space. Some of these tasks may include work at height, lifting operations, excavation works, temporary structure erection, energy sources, fire hazards and traffic. One of the key risks is interface risk, whereby each company performs their task independent of others but fails to understand that the combination is dangerous to all organizations. Literature on high rise building construction shows how the combination of height and complexity increases fire, maintenance and evacuation risks (Konar, 2025). For urban development projects, these risks are replicated with districts, tunnels, bridges, utility networks, podium structures, and transport links. Secondly, an important thematic area to consider is health. In Saudi Arabia, construction works happen during climatic conditions which expose workers to heat. Heat influences the quantity of work performed, mental abilities, and occupational health. As a result, health protection strategies go beyond the use of water supplies and safety posters. Health protection strategies should involve worker breaks, designated rest areas, acclimatization, medical preparedness, training, supervisory measures and accountability of subcontractors. Recent literature on occupational health in the Saudi construction industry also shows that worker health is an emerging theme concerning occupational stress, communication barriers, and varied safety standards among multicultural workers (Alruqi, 2025). Thirdly, another thematic area is environmental issues. Urban development leads to production of dust, noise, waste generation, water pollution, light pollution, and consumption of resources. Literature on sustainable construction emphasizes the need for minimizing the environmental impact in terms of carbon footprint reduction, waste segregation, water management, and application of the circular economy framework (Benachio et al., 2020; Ghaffar et al., 2020). For the Saudi construction industry, these themes arise within the context of an arid environment, sensitive desert ecosystems, coastal zones, protection of groundwater resources, and society's desire for sustainable urban living. As a result, EHS performance has to include environmental monitoring as part of daily project controls.

Fourthly, another thematic area is technology enabled performance. BIM can be used for safety planning in terms of identifying clashes, access, edges and schedule. Sensors can be used to monitor dust, noise levels, temperatures, vibrations, equipment statuses and workers' exposure. Drones are useful in inspecting elevated objects, confined spaces, stock piling, and traffic flow. Wearables can be used for monitoring proximity, temperature levels, and fall risk. Digital twins can be used for linking construction progress to hazards, and preparing emergency plans (Kineber et al., 2024; Dodoo et al., 2024). Technology presents challenges too in terms of cybersecurity, alarm flooding, technology

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fragmentation, and sub-contractor exclusion from systems.

Fifthly, another issue is emergency preparedness. Literature on emergency preparedness and disaster management in Saudi Arabia has emphasized the need for inter-operation, communications, technological tools, and community preparedness (Mani et al., 2023). In the context of construction projects, similar requirements apply. Emergency preparedness relies on having an appropriate command system, rescue routes, assembly points, first aid facilities, multilingual warnings, firewater supply, drills, and coordination with other public authorities. Mega projects constitute temporary cities. As a result, emergency preparedness has to include traffic management, facilities, clinics, cranes, tunnels, hazardous materials and weather risks.

In conclusion, literature indicates that EHS optimization is achieved through the integration of prevention, monitoring, response and learning. This is through the use of leading indicators in terms of closure of major hazards, good toolbox talks, supervisor's presence, heat management, environmental exceedances, permits and emergency drill outcomes. Leading indicators are very important, but lagging indicators are not left out in this process of learning.

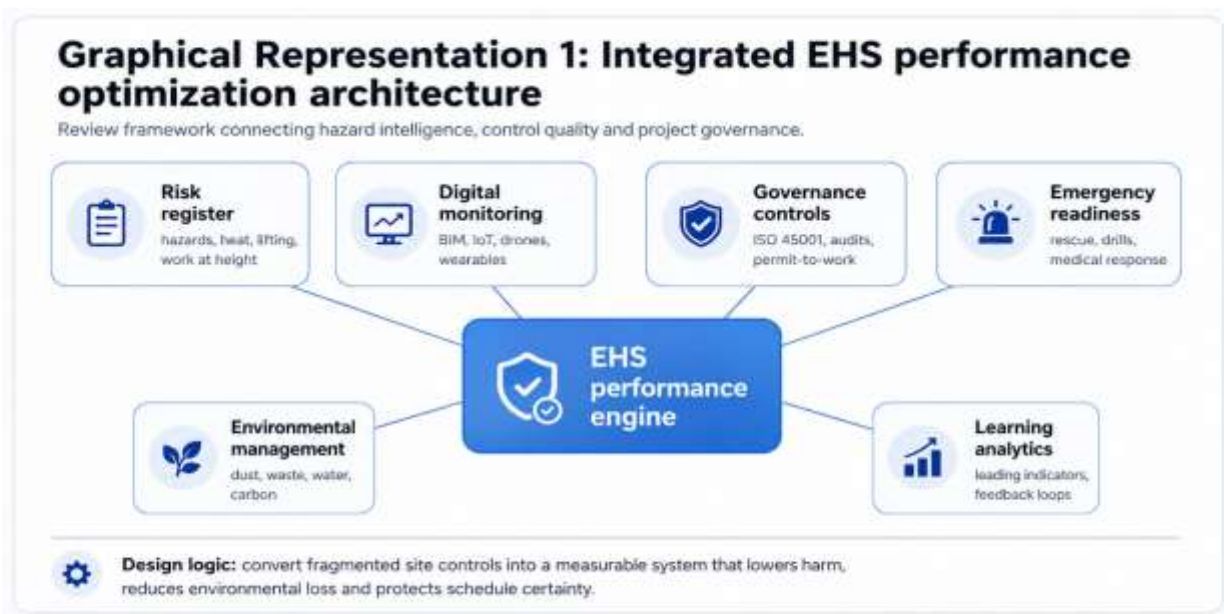


Figure 1. Integrated EHS performance optimization architecture for Saudi mega construction projects

## V. EHS PERFORMANCE OPTIMIZATION FRAMEWORK FOR SAUDI MEGA PROJECTS

The framework comprises five interlinked layers. Layer one is leadership and governance. Clients should set their EHS expectations at the procurement stage, ensure competence of contractors through quantitative measures, and link their commercial incentives to prevention. In mega projects, fragmented contracting may push the risks down the supply chain. In an optimized solution, EHS will be a shared value with defined responsibilities of the client, programme manager, designer, contractor and subcontractor from the design phase to handover. Risk-based assurance, independent audits, reporting and incident review by the board will be part of governance. Layer two is design and planning. Most hazards are introduced during the design phase when workers are yet to appear on the job sites. Design-for-safety reviews can examine the constructability, temporary works, access, lifting strategy, façade installation, excavations, fire compartmentation, maintenance access and evacuation procedures. BIM-based planning can test sequences, congestion issues

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and logistics routes. In urban development projects, environmental design reviews should consider drainage, dust suppression, waste storage, sustainable materials, efficient water use and sustainable procurement. Such an approach recognizes the fundamental EHS philosophy that prevention beats control. Layer three is field execution and worker health. Daily performance of EHS relies on supervisors, foremen and field crews. Basic controls will involve permits, lifting plans, lockout/tagout, edge protection, confined spaces, traffic management, inspection of plant and verification of temporary works. Health controls will include heat stress management, provision of rest facilities, hydration, fatigue monitoring, medical screening, occupational hygiene and mental well-being programs. As most Saudi mega projects involve multi-national workforce, communication should be multilingual, visual and behavior-oriented. The engagement of workers is vital as they are best positioned to detect any inadequacies of controls.

Layer four is environmental responsibility. Controls related to environment should be incorporated in the production planning of construction work. Monitoring of dust and particulate should inform suppression, haul-road management and use of enclosures. Noise and vibrations should be managed using scheduling, barriers and maintenance of equipment. Waste streams need to be monitored based on type, source, destination and recovery. Water usage needs to be tracked in terms of consumption, re-use and quality of discharge. Carbon footprint could be minimized through material choice, logistics, low-emission machinery and use of renewable energy where applicable. Performance monitoring should use a dashboard format, which combines both safety and environmental performance. Layer five is analytics and continuous improvement. Digitization can capture observations, inspections, permits, incidents, environmental measurements, equipment status and drill performance. Through analytics, repetitive non-conformances, hotspots, trends and predictive indicators can be identified. Technology should help organizations learn rather than blame. Reporting of near misses should be protected. Root cause analysis should go beyond human error. Corrective actions should be validated for effectiveness. The most optimized system is therefore the learning loop which involves sensing, prediction, control, response and learning.

This framework is highly relevant to Saudi Arabia given the importance of mega-project performance to national reputation, investment confidence and quality of life considerations. Failure to meet EHS standards may result in negative impacts such as eroding social trust and delaying critical infrastructure. Conversely, excellence in EHS performance could lead to greater productivity through reduced rework, stoppage, medical cases, disputes and regulatory delays.

Table 2. Practical EHS performance scorecard for mega construction and urban development projects

| Performance domain | Leading indicators | Lagging indicators | Digital enabler | Management decision |
|---|---|---|---|---|
| Safety control quality | Closed critical observations; permit audit score | Lost-time injuries; serious incidents | Mobile inspection and BIM sequence review | Redirect supervision to repeated weak controls |
| Worker health | Heat-plan compliance; hydration and rest checks | Heat illness; clinic referrals | Weather stations and wearable health alerts | Adjust shifts, rest cycles and medical resources |
| Environmental stewardship | Dust exceedance closure; waste recovery rate | Spills; regulatory notices | IoT monitoring and waste tracking | Modify methods, logistics and supplier choices |
| Emergency preparedness | Drill findings closed; response-route | Response delay; evacuation | Digital muster, GIS and communication systems | Update command roles and scenario plans |

| | | | | |
|---|---|---|---|---|
| | availability | failures | | |
| Learning maturity | Near-miss quality; root-cause completion | Repeat incidents; unresolved actions | Analytics dashboard and trend forecasting | Revise standards, training and procurement controls |


Figure 2. Risk-to-performance learning loop for Saudi mega-project EHS optimization

## VI. DISCUSSION: STRATEGIC IMPLICATIONS AND TRADE-OFFS

Implications The main one is that EHS optimization should be considered as project performance together with cost, schedule, and quality management. Safety and environmental controls used to be viewed as constraints for a long time. As shown by the current research, a robust safety system will contribute to the efficiency of production thanks to fewer interruptions, improved discipline among planners and increased trust of employees (Kedir et al., 2024; Alruqi, 2025). That is why it is vital to focus on the problem because even a slight delay can put national development plans at stake and raise suspicions in investors.

At the same time, it has to be admitted that there are some drawbacks associated with this approach. In particular, enhanced digital monitoring tools will improve the identification of hazards but can create information overkill and privacy issues. Permits will save any mega project from disasters but an excessive amount of paperwork will turn people into mere rule followers because of poor supervisor training. Environmentally oriented measures will

initially increase expenses but a failure to control pollution, wastes, and water consumption will result in conflicts with the community and liabilities. Emergency drills will add to efforts but reveal deficiencies in communication and accessibility of equipment. EHS management optimization always involves decisions made based on assessments of risk factors. As one can see from the attached Springer model, mega urban projects face not only financial, technical, and logistic risks but also those concerning fire safety, environment, and maintenance that require innovation (Konar, 2025). The same concerns EHS management as well. The more complex a project is, the higher risk of relying on inspections exists. Hence, professionals involved in EHS should get involved in design reviews, purchasing, logistics, data management, and emergency response planning. In addition, a shift to environmental optimization should be made by EHS professionals. Last but not least, project managers should consider whether the pressure of production affects EHS controls' effectiveness. Another implication refers to the ecosystem of contractors. The fact is that Saudi mega projects imply subcontracting and collaboration of foreign organizations. These practices introduce additional competencies but create an opportunity for fragmentation. Adoption of the common platform for EHS assurance through standardizing such elements as terminology, forms, risk assessment procedure, education requirements, and templates would mitigate the risk. However, it does not mean that site-specific approaches should be rejected. Different interfaces – coastal, desert, high-rise, underground, and industrial – require special attention. Thus, the best strategy would be adoption of the common governance model combined with local risk assessments.

The next aspect that should be highlighted pertains to impacts on the community and the public realm. Indeed, construction occurs near residences, streets, pilgrim routes, tourism attractions, commercial properties or future residents. For this reason, EHS controls should not be limited to construction processes but consider the possible risks of the surrounding population such as traffic control, pedestrian segregation, provision of emergency routes, dust mitigation, information sharing, and participation of concerned parties. This approach corresponds to sustainable infrastructure development principles which imply that there cannot be any successes if risks are transferred to adjacent communities. Finally, one more aspect pertains to emergency preparedness. Fire accidents, flooding, falls of cranes, heat strokes, confined space rescues, and mass casualty incidents require a clear plan of action during emergency situations. The disaster management literature emphasizes that interoperability and innovation play a significant role in emergency response in Saudi Arabia (Mani et al., 2023). The same applies to the construction projects as customers should ensure the possibility for contact between all emergency teams, guards, medical staff, civil protection, and transport units as well as neighbours.

## VII. IMPLEMENTATION ROADMAP AND PRACTICAL RECOMMENDATIONS

Such a roadmap should begin prior to mobilization. During the concept design phase, the client is supposed to have the EHS maturity plan, specifying how the hazards could be designed out of the equation, how environmental considerations map the project, and how emergency response should be tested. The said plan should be accounted for during procurement, since the client may hire a contractor for financial savings and programme assurance reasons, regardless of safety concerns. At the same time, procurement should require evidence of competent supervision, temporary works management ability, heat stress ability, environmental monitoring ability, incident investigation skills and multilingual training. Early involvement of contractors is also beneficial because designers are often ignorant of the sequence, equipment, access conditions and logistics involved in high rise and deep excavation rescues.

During the pre-construction phase, the maturity plan should be translated into the risk register. The risk register needs to be both temporal and spatial. A generalized list of hazards does not work for tunnel projects, bridges, tower cranes, utility works, road diversions and public interaction. Hazards have to be assigned owners, with design and method controls, inspection frequencies and escalation criteria listed. In addition, baselines for environmental monitoring should be set, including air quality, noise, vibration, flows, water consumption and sensitive receptors. Baseline data are required to prove environmental impacts of the project. Furthermore, a test of emergency response measures has to be undertaken before the maximum manpower is brought on site. Namely, ambulance routes, rescue equipment, firewater access points, muster points, communication procedure, emergency leadership roles and contact persons for public authorities should be established. During the construction phase, the roadmap should operate in a loop of performance. The coordination meeting should address hazards, environmental issues and any change of emergency response conditions on daily basis. Assurance assessments have to be based on control effectiveness and not mere volume of inspections done weekly. The leadership reviews should pinpoint potential incidents, heat stress events, exceedances, poor subcontractor performance, remediation actions closure and lessons learned. Put differently, the project has to predict lifting and excavation mishaps ahead of time. Leading indicators have to be analysed for their potentially lethal influence. For example, ten observations on housekeeping do not add up to one unauthorized lift over an access route. The next essential part of the roadmap should address roles and responsibilities related to digital technology. BIM modelling should validate construction sequence, exclusion zones, temporary access arrangements and maintainability. Where drone surveying could reveal some inaccessible zones, such decisions have to be made by the engineer, not the machine. Wearable devices could help to reduce heat stress risks and proximity accidents provided that this tool is transparent and explained to employees. Environmental monitoring systems should trigger responses, such as haul route adjustment, increased suppression efforts and activity relocation. Dashboard should serve as an analytical tool helping decision making. Effective dashboard should warn senior leaders of rising risk levels, poorly performing contractor, pending corrective actions and design and logistical issues causing continuous exposure.

Training and competency management is another critical aspect to be addressed. Large scale projects require role and situational training for executives, engineers, supervisors and workers. Executives have to be educated in risk governance, business pressures and crisis management. Engineers should be trained in design for safety principles, temporary works and environmental aspects. Supervisors have to be instructed how to confirm field conditions, how to communicate effectively and when to stop operations. Workers need clear explanations and visual aids on top of the guarantees of no punishment for hazards reporting. Emergency response teams require frequent and realistic drills, including night hours, limited traffic, extreme heat and multiple casualties. Each drill and near miss event have to be analysed from the standpoint of training. In terms of handover and operation, large urban development's mean transfer of many sites to operators, municipalities and facilities managers. Failure to recognize maintenance access points, fire protection, confined spaces, facade cleaning, waste rooms, plant rooms and emergency access routes can create many risks post-completion. In this respect, final EHS files should contain not just compliance certificates, but also residual risks, inspection history, environmental impact assessment and emergency response lessons learned. Such life cycle approach is grounded in sustainable infrastructure concept, which implies that the safest project is one where contractor and end user can safely interact. Based on the foregoing, several recommendations for Saudi mega-project clients emerge. Firstly, they should insist on adoption of an EHS data dictionary for all packages. The clients require a single coding system for incidents, observations, environmental monitoring and assurance assessment. Secondly, the client should focus on severity of incidents rather than frequency of occurrence in order to estimate maturity level. The said recommendation is grounded in the low injury frequency rate and immature reporting culture. Thirdly, the client should incorporate both environmental and safety aspects in project planning meetings. The same activity poses hazards to construction and the surrounding environment. Fourthly, the client should address heat stress issues from a strategic perspective, implying proper scheduling. Fifthly, independent audits should examine knowledge of critical controls among sub-contractors. Sixthly, lessons learned across many projects should be documented in publicly accessible reports. The next stage of research to be conducted within academia and public domain involves creation of a national EHS maturity model for construction programmes in Saudi Arabia. The model would help the client to hire the contractor, provide contractors with benchmarking instruments and regulators with insights regarding maturity level of the industry. The academic community and professional associations could undertake case studies on prefabricated materials, digital permits, wearables, water reuse and low carbon emissions to minimize actual risk. The said approach would move the industry from adoption of foreign best practices to development of locally adapted solutions. As part of the roadmap, worker welfare has to be addressed. Accommodation conditions, means of transport, food hygiene, rest opportunities, medical services, and grievances mechanism contribute to EHS assurance as a tired worker would fail to observe hazards and challenges risk factors. This way, welfare audits should be incorporated into EHS audits especially in remote locations lacking health care facilities and other social services. Project management must foresee potential climate uncertainties. Rainfall, flooding, dust storms and heat waves may radically change risk landscape within hours. Climate induced action plan should prescribe lifting suspension, outdoor operations suspension, excavation inspection and reassignment of emergency resources. The last step in optimizing processes involves building trust. The employees may refrain from near miss reporting due to possible sanctions while subcontractors would hide signs due to business interests. Just culture distinguishes between errors, systemic weakness and violations and encourages learning without letting offenders off scot-free. In context of megaprojects, trust cannot be viewed as management concept but as infrastructure for information sharing. The final tool for EHS assurance during large scale construction project is a verification walk involving senior leaders with engineers, supervisors and worker representatives. During verification walks, senior leaders are to question the presence and maintainability of barriers preventing fatal incident. Verification walks reveal how corporate commitment is transformed into reality and draw attention to shortcomings of interface management. Moreover, it demonstrates to all involved parties that productivity must never prevail over life-saving measures and environmental protection.

## VIII. RESEARCH GAPS AND FUTURE DIRECTIONS

Some research areas need further investigation as well. First, data on EHS performance in Saudi giga and mega projects needs to be opened to develop anonymous benchmarking database on leading indicators of success, heat stress compliance, major incident possibilities, exceedances, and emergency drill proficiency. Second, additional empirical research is required in the field of impact of multilingualism on hazards detection and stop-work power. Third, digital tools have to prove their reliability, privacy policy, worker satisfaction, and inter-contractor compatibility on Saudi construction site reality. Fourth, environmental performance requires further investigation based on direct connection to the method of building itself, such as modular construction, prefabrication offsite, use of low carbon footprint materials, electric plant, recycled water, and circular waste model. Fifth, the emergency response management topic needs to investigate the issue of huge worker population size, remote desert locations, urban interface, and severe weather phenomena. Sixth, the future models of EHS have to incorporate financial analysis to make executives see prevention as a form of value generation.

## IX. CONCLUSION

In conclusion, this review suggests that environmental health and safety optimization for Saudi mega construction and urban development projects require a comprehensive and strategic approach. Firstly, the size of the infrastructure projects under Vision 2030 results in very high levels of exposure risk related to occupational injuries, environmental consequences, disruptions to the public order, and emergency situations. Secondly, while compliance mechanisms are essential for ensuring EHS performance, they are insufficient. The best-performing company in this respect combines all elements of EHS in one system of continuous improvements.

It is possible to argue that the above-stated framework will prove that EHS can serve both people and projects. Design reviews help minimize risks related to hazardous tasks. Digital solutions enhance the tracking of changes in risks throughout the lifecycle of the project. Workers' health programs limit their exposure to heat, fatigue, and stress. Environmental dashboards promote responsible urban development initiatives. Emergency preparedness through drills helps deal with rare yet highly impactful incidents. From the perspective of Saudi Arabia, this framework will contribute to sustainable infrastructure development under the Vision 2030 strategy.

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