



# A Proposed Conceptual Model for Safety Management in Sustainable Construction Projects

Afaf Hassan

Department of Environmental and Public Health, Abu Dhabi University, Abu Dhabi,  
United Arab Emirates

**Abstract:** This study develops a conceptual model integrating Safety Management (SM) into Sustainable Construction Projects (SCPs) to achieve safe and sustainable outcomes. The model consists of three interrelated stages: Safety Management Inputs in SCPs, Safe Work Conditions (SWCs) in SCPs, and Safety Management Outcomes in SCPs. It highlights that SM inputs, such as clear safety policies, leadership commitment, adequate training, and digital innovations, are essential to initial safe work environments that enhance sustainability and overall performance. Safe work conditions, in turn, improve operational efficiency, hazard control, and worker well-being, leading to measurable safety management outcomes like strengthened safety culture, reduced accidents, and improved compliance. The proposed conceptual model contributes theoretically by relating safety management to sustainability goals and practically by offering a structured guide for managers to embed safety management into sustainability-driven construction practices. Although conceptual in nature, the research sets a foundation for future empirical validation, managerial studies, regional adaptation, and application in broader sustainable development contexts.

**Keywords:** safety management, sustainable construction projects, safe work conditions, sustainability, conceptual model

## 1. Introduction

The construction industry is commonly identified as one of the most hazardous sectors because of its temporary, decentralized, and dynamic nature (Li et al., 2015). From infrastructure development to recent megaprojects, construction has regularly posed risks to organizational operations, societal welfare, and human health (Hewage et al., 2011; Lee & Son, 2021). The complication of large-scale projects, characterized by multiple disciplines, intricate structures, evolving site conditions, and heavy machinery, increases safety challenges (Li et al., 2021). Factors such as harsh environments, high workloads,

overlapping tasks, and long project durations further increase the potential for hazards (Li et al., 2021; Lee & Son, 2021). Empirical evidence signifies that construction continues to report the highest industry fatality rates, emphasizing the necessity for proactive safety management (Boyd & Bentley, 2012).

Alongside, sustainable construction has emerged as a core paradigm, highlighting environmentally responsible, socially equitable, and economically efficient practices throughout a project's lifecycle (Chong et al., 2025; Gunduz & Almuajebh, 2020; Mensah et al., 2018). Sustainable construction projects intend to reduce environmental impact through

energy- and water-efficient designs, renewable and recycled materials, habitat protection, and waste reduction while sustaining structural quality and economic viability (Gharehbaghi & McManus, 2003; Heravi & Faeghi, 2014; Lee & Son, 2021). Yet, embedding sustainability adds complexity, requiring improved safety oversight, communicable risk management, and alignment between human safety and environmental objectives (Tahmasebinia et al., 2020; Udomsap & Hallinger, 2020; Zhang et al., 2020). Safe and sustainable construction demands leadership commitment, workers' participation, education, training, and behavioral change, along with environmental compliance (Chong et al., 2025; Hassan, 2021d; Okoye & Okolie, 2013).

Safety management is a widely known systematic approach to managing risks, including policies, procedures, and organizational structures to avoid injury, accidents, or loss of life, and to prevent property damage (Chong et al., 2025). SM encompasses structured procedures, processes, and policies designed to efficiently identify and mitigate risks, ensure operational safety, and control hazards (Kukoyi & Adebawale, 2021; Tahmasebinia et al., 2020). Main components comprise safety policies, leadership commitment, training and communication, hazard identification and mitigation, safety monitoring, incident reporting, auditing, and continuous improvement (Kukoyi & Adebawale, 2021; Lee & Son, 2021).

In SCPs, following safe work conditions is essential to maintain safety. SWCs represent a core mediator between safety inputs and outcomes in sustainable construction projects (Afanasyeva et. al., 2020; Hassan et al., 2025b; Liwång, 2020). They encourage shared responsibility between employees and their employers, adherence to safety rules, adequate training, timely hazard reporting, and proper use of personal protective equipment (PPE). Necessary elements include proper PPE, emergency exits, ventilation, noise control, safe and well-maintained equipment, sufficient lighting, clear signage, clean workspaces, safe access paths, ergonomic setups, temperature control, and waste management (Fukuda-Parr & Muchhala, 2020; Hassan, 2023a; Rahman et al., 2022). Assuring safe conditions not only prevents accidents but also boosts employee organizational performance, morale, and well-being, while meeting ethical and legal obligations (Ciegis et al., 2011; Hassan et al., 2025a; Zhang et al., 2020).

However, this study aims to integrate safety management in sustainable construction projects through developing a conceptual model, which illustrates how to establish safe sustainable construction projects. Even though numerous studies address safety management and sustainable construction individually (Gunduz & Almuajebh, 2020; Lee & Son, 2021; Okoye & Okolie, 2013; Tahmasebinia et al., 2020; Udomsap & Hallinger, 2020; Yiu et al., 2018; Zhang et al., 2020), fewer studies

investigate their integration (Dewlaney & Hallowell, 2012; Hassan, 2021a; Liwång, 2020; Marhaviyas et al., 2018).

Accordingly, the proposed conceptual model represents a systematic approach to integrating safety within existing sustainability practices in construction projects. It highlights the continuous relationship between SCPs' inputs, safe work conditions, and outputs, bridging the gap between safety principles and sustainable construction practice. Its significance lies in proposing a practical roadmap for policymakers, managers, and researchers to apply, improve, and monitor safety practices in SCPs.

## 2. Methodology

This research employs a literature-based methodology to utilize existing knowledge on safety management and sustainable construction projects, then proposes a conceptual model. This literature-based approach led to the development of a theory-driven model in the fields of safe management and sustainable construction research (Snyder, 2019; Xiao & Watson, 2019). The literature review was organized into three main phases: (1) safety management practice, (2) safe work conditions in sustainable construction, and (3) the interlinkages between safety management and SDPs.

Initially, 86 peer-reviewed journal articles were selected through searches in databases such as Abu Dhabi University online library, Web of Science, and Google Scholar, focusing

on publications between 2010 and 2025 that studied the relationship between safety management and sustainability in construction projects (Moher et al., 2009). The initial pool was then refined to 54 high-relevance studies based on a specific inclusion criterion, which required recent, rigorous methodology and thematically relevant work that is consistent with best practices in systematic and integrative literature reviews (Snyder, 2019; Tranfield et al., 2003).

Insights from the selected research papers were coded and synthesized thematically, following an iterative thematic content analysis and conceptual categorization to identify recurring existing relationships and patterns (Dewlaney & Hallowell, 2012; Hassan, 2021a; Kim et al., 2020). This process yielded three interrelated phases that constitute the proposed model: safety management input, safe work conditions in SCPs, and SM output in SCPs. While this study remains conceptual, it draws upon theoretical and empirical evidence from thoroughly reviewed literature to support its associations, assertions, and suggestions (Kukoyi & Adebowale, 2021; Loushine et al., 2006; Snyder, 2019). The resulting model guides future hypothesis development, model testing, and empirical validation across different sustainable construction contexts.

## 3. Literature Review

A thorough literature review was conducted to introduce how safe and sustainable construction projects can be established. The

review involves a general overview of safety management in construction projects, SM inputs in sustainable development projects, safe work conditions in SCPs, safety management outcomes in SCPs, and insights about integrating SM into SCPs as demonstrated in the following sections.

### 3.1 Safety Management in Construction

Safety management is defined as the use of structured components, processes, and policies to mitigate hazards, boost a proactive safety culture, and enhance safety performance (Kukoyi & Adebawale, 2021). Key elements of SM include safety policies, risk identification and mitigation, allocation of safety resources, standardized procedures, safety training, incident reporting, accident investigations, auditing, human factors and system design, continuous improvement, change management, and safety monitoring (Kukoyi & Adebawale, 2021; Lee & Son, 2021). These elements are not just theoretical ideals but should be operationalized and implemented to achieve measurable outcomes.

Lately, safety management has changed from a compliance-centric approach to a behaviorally oriented framework, highlighting visible proactive behaviors, safety practices, and continuous improvement (Okoye & Okolie, 2013). Efficient communication channels between management and employees, clear role allocation, and participatory engagement are essential to ensure that safety procedures are adhered to in accordance with international

standards (Kukoyi & Adebawale, 2021; Lee & Son, 2021). Yiu et al. (2018) stated the holistic nature of SM by integrating planning, organizing, implementing, and assessing safety policies, adopting periodic audits that provide safety performance feedback.

Furthermore, the complexity of operations requires intensified safety oversight compared to other industries. Workers frequently move across work with heavy machinery, evolving site layouts, and are exposed to varying environmental conditions, increasing the likelihood of accidents (Ciegis et al., 2011; Kim et al., 2020; Li et al., 2015; Lee & Son, 2021). Every construction site has a unique incident history and risk profile, covering site mitigation strategies and continuous monitoring (Hewage et al., 2011; Kukoyi & Adebawale, 2021; Yiu et al., 2018). Scholars agreed that most construction accidents could be prevented via systematic safety planning, effective training, frequent inspections, and corrective action methods (Kim et al., 2020; Kukoyi & Adebawale, 2021; Liwång, 2020; Park & Hyeon-Jin, 2013).

Previous studies often limited safety management to planning, inspection, and training (Kim et al., 2020; Park & Hyeon-Jin, 2013). Recent research extended these boundaries to involve tailored hazard responses, task or activity risk identification, and enhanced communication between management and assigned workers (Kukoyi & Adebawale, 2021; Lee & Son, 2021; Liwång,

2020). Li et al. (2015) mentioned nine factors influencing safety at the workplace, which are safety management, PPE usage, working environment, perceived risk, self-efficacy, self-esteem, training, productivity pressure, and safety attitude, emphasizing that well-trained safety personnel minimize management overhead and enhance overall safety outcomes.

Safety management approaches follow a compliance-based approach, emphasizing adherence to procedural and legal requirements, or a corrective method, through applying proactive hazard identification and rectification (Boyd & Bentley, 2012; Ladewski & Al-Bayati, 2019). Reliable safety systems often integrate both methods, ensuring that regulatory compliance is maintained while sustaining a culture of continuous improvement (Kukoyi & Adebawale, 2021; Ladewski & Al-Bayati, 2019; Lee & Son, 2021; Liwång, 2020). Continuous auditing and reviews remain necessary to evaluate performance, detect gaps, and improve safety processes (Yiu et al., 2018).

### 3.2 Safety Management Inputs in SCPs

Safety management input for sustainable construction projects includes numerous elements to be achieved. Clear safety policies need to be aligned with sustainability goals (Fortunato et al., 2012; Kukoyi & Adebawale, 2021). Effective top management support that encourages a culture of safety and sustainability, where workers adopt safe practices (Okoye & Okolie, 2013; Robichaud & Anantatmula, 2011; Liwång, 2020). Adequate

(human, financial, and technical) resources should be dedicated to safety planning, training, and monitoring activities (Hassan, 2023b; Kim et al., 2020; Gunduz & Almuajebh, 2020). Continuous identification and assessment of risks are crucial to managing the dynamic and complex nature of SCPs (Li et al., 2021; Marhavidas et al., 2018). The efficient implementation of engineering controls, PPE to eliminate or minimize hazards and administrative measures contributes to more effective SM in SCPs (Lee & Son, 2021). An ongoing safety education ensures supervisors and workers are equipped with the knowledge and skills needed to work safely and sustainably (Yiu et al., 2018). Open communication channels motivate workers to share ideas, report hazards, and participate in safety decision-making (Chong et al., 2025; Hassan, 2020; Gunduz & Almuajebh, 2020). Frequent evaluation of safety metrics, such as incident rates and near-miss reports, ensures continuous feedback and improvement (Rahman et al., 2022). Root-cause analysis and systematic reporting of accidents and near misses improve learning and prevent their recurrence (Afanasyeva, 2020; Liwång, 2020). Consistent safety audits and feedback help enhance policies and processes to align with safety and sustainability targets (Ladewski & Al-Bayati, 2019). Managing safety consequences during design or operational changes ensures that any new risks occurring are addressed proactively (Ladewski & Al-

Bayati, 2019; Zacchei & Molina, 2020). Ultimately, the use of safety technologies, such as Building Information Modelling (BIM), Internet of Things (IoT) sensors, and AI-based safety systems, improves monitoring and enhances predictive safety management (Chong et al., 2025; Gunduz & Almuajebh, 2020).

### 3.3 Safe Work Conditions in SCPs

Safe work conditions are also known as a safety management system. In construction, the SWCs utilize a structured and cycle-based method to ensure a safe worksite. This is achieved by checking for and resolving any existing hazards before work begins. SWCs involve raising workers' awareness, conducting regular safety checks, and ensuring that safeguards and life-saving controls are in place (Greenwood & Wu, 2012; Hassan, 2021c; Zhang et al., 2020). Further, safe work conditions in SCPs are necessary to protect workers' health and well-being while maintaining the broader sustainability goals. These conditions involve both organizational and physical elements that collectively reduce hazards, prevent accidents, and ensure effective operations (Gunduz & Almuajebh, 2020; Kattan & Hassan, 2010; Yiu et al., 2018). A safe work environment in SCPs should address the distinctive challenges related to evolving construction sites, new materials, and complicated project requirements (Gunduz & Almuajebh, 2020; Li et al., 2021). In construction projects, SWCs involve emergency exits, clean workspace, proper PPE,

ergonomic setup, good ventilation, adequate lighting, safe equipment, noise control, clear signage, temperature control, waste management, and safe access paths (Greenwood & Wu, 2012; Hassan et al., 2025b; Zhang et al., 2020). On the other hand, SWCs in SCPs comprise four main categories, each of which includes key elements. First, a physical category including PPE, clean workspace, lighting, ventilation, and safe access (Okoye & Okolie, 2013; Liwång, 2020). Second, an environmental category involving noise reduction, waste control, and equipment maintenance (Zhang et al., 2020). Third, an organizational category covering communication, training, emergency plans, and audits (Li et al., 2021; Rahman et al., 2022). Last, a technological category comprises Internet of Things (IoT) sensors, Building Information Modeling (BIM), and Artificial Intelligence (AI) safety tools (Greenwood & Wu, 2012; Chong et al., 2025). Beyond these tangible aspects, other factors such as management commitment, clear communication, safety training, incident investigation procedures, and hazard reporting systems are equally important for compliance and continuous improvement (Kukoyi & Adebawale, 2021). Research also emphasizes that SWCs are not achieved solely through compliance; they require a culture of safety (Hassan, 2021a; Kukoyi & Adebawale, 2021). In SCPs, this culture should align with broader environmental and social objectives, such as

reducing environmental hazards, minimizing material waste, and ensuring equity in occupational health and safety standards (Chong et al., 2025; Gunduz & Almuajebh, 2020; Hassan, 2023c).

### 3.4 Safety Management Outcomes in SCPs

The outcomes of implementing safety management in sustainable construction projects are many. In this research, the main outcomes are emphasized to highlight the importance of safe and sustainable construction projects. For example, safer worksites and fewer incidents (Dewlaney & Hallowell, 2012; Kim et al., 2020), improved health and well-being that can be seen in workers' physical and mental safety (Okoye & Okolie, 2013; Li et al., 2021; Sachs, 2012), robust safety culture involving proactive awareness and participation about safety and sustainability (Yiu et al., 2018; Gunduz & Almuajebh, 2020), higher productivity due to improved efficiency and fewer project delays because incidents will decrease (Rahman et al., 2022), and regulatory compliance that lead to adherence to standards and reputation gains (Lee & Son, 2021). In addition, other scholars highlighted additional outcomes of SM in SCPs. For instance, waste reduction results in less energy waste and material loss (Chong et al., 2025; Gunduz & Almuajebh, 2020). Continuous improvement through encouraging ongoing learning and innovation in safety (Rahman et al., 2022). Employee satisfaction is improved due

to improvements in morale and retention (Hassan, 2021b; Liwång, 2020). Stakeholder confidence, which is shown because of mutual trust and social acceptance (Wu et al., 2017; Zacchei & Molina, 2020). Eventually, integrated sustainability that covers environmental, social, and economic alignment (Li et al., 2021)

### 3.5 Integrating SM into SCPs

Integrating safety management into sustainable construction projects helps in achieving both safety and sustainability goals (Hassan, 2021a; Robichaud & Anantatmula, 2011). The integration process covers three main phases: SM inputs in SCPs, safe work conditions in SCPs, and SM outcomes in SCPs. Each stage contributes to building an inclusive conceptual framework that ensures environmental responsibility, operational efficiency, and worker well-being. In clarification, the first stage forms the basis of an efficient safety system, which ensures that safety and sustainability are embedded from the design and planning stages through construction and maintenance. The second stage aims to create and maintain safe work conditions that reduce occupational risks while adopting sustainable practices. ensuring compliance with both safety and environmental standards. When SM inputs are effectively implemented and SWCs are maintained, the third stage demonstrates a culture of safety integrated into sustainability frameworks, ensuring SCPs not only meet environmental

targets but also safeguard human health and welfare (Hassan et al., 2025a; Fukuda-Parr & Muchhala, 2020; Liwång, 2020).

Nevertheless, integrating SM into SCPs through structured inputs, sustained SWCs, and measurable outcomes ensures a balance between safety and sustainability objectives. This integrative approach transforms construction projects into safer, sustainable, and more efficient ones, where safety coexists harmoniously to achieve sustainable success.

#### 4. Development of the Proposed Conceptual Model

Using the information collected from the thorough literature review, the proposed conceptual model is shown in Figure 1. It demonstrates how safety management can be successfully integrated into sustainable construction projects through three sequential stages: safety management inputs in SCPs, safe work conditions in SCPs, and SM outcomes in SCPs. It demonstrates a structured association between the foundational elements of safety management, their possible application in sustainable construction projects, and the subsequent performance outcomes that align safety management with sustainability objectives.

Each stage represents elements extracted from the comprehensive literature review of this study. The first stage, safety management inputs in SCPs, represents the foundation of SM integration in sustainable construction projects. From the comprehensive literature

review, safety management inputs can be summarized to include safety policies, safety objectives, leadership commitment, safety culture, resource allocation, hazard identification, risk assessment, risk control, mitigation measures, safety training, competency development, effective communication, worker participation, safety monitoring, incident reporting, incident investigation, auditing, continuous improvement, and change management, and integration of digital tools (Dewlaney & Hallowell, 2012; Gunduz & Almuajebh, 2020; Kattan & Hassan, 2010; Liwång, 2020). These inputs ensure that SM is embedded as a strategic priority rather than a regulatory obligation. The second stage, SWCs in SCPs, translates safety management inputs into practical safety practices. Safe work conditions demonstrate the operational environment where safety and sustainability converge. Elements involved clean workspace, proper PPE, safe access, adequate lighting, good ventilation, waste control, noise reduction, equipment maintenance, emergency plans, communication, training, audits, IoT sensors, BIM, and AI safety tools (Hassan & Al-Ali, 2024; Secundo et al., 2020; Zacchei & Molina, 2020). These elements extend to environmentally responsible practices such as adopting energy-efficient systems, recycling materials, and minimizing pollution, which complement individuals' safety and ecological goals (Gunduz & Almuajebh, 2020; Liwång,

2020). When meaningful inputs and safe work conditions are attained, they lead to measurable outputs that identify the last and third stage. The third stage, SM outcomes in SCPs, covers reduced accidents, better health and well-being, stronger safety culture, higher productivity, regulatory compliance, waste reduction, continuous improvement, employee satisfaction, stakeholder confidence, and integrated sustainability (Liwång, 2020). Such outcomes contribute to the well-being of workers, organizational resilience, and project success.

In addition, it is important to understand the interconnection between the three main Stages. Each stage in this model builds rationally upon the preceding one. Safety Management inputs, such as structured policies, strong leadership, and advanced technologies, form the base for SWCs on-site. These safe work conditions directly influence SM outputs, leading to measurable improvements in the overall culture and performance. Collectively, these outcomes contribute to the principal goal of safe and sustainable construction, where human safety and environmental objectives are attained concurrently. This sequence highlights the interdependence of each element and the need

for continuous alignment between safety management and sustainability targets (Fortunato et al., 2012; Gunduz & Almuajebh, 2020; Liwång, 2020; Wiek et al., 2011).

Moreover, safe and sustainable Construction projects can be achieved by following the stages of this model. The proposed model is a clear representation of the effective integration of safety and sustainability outcomes in SCPs. Achieving safe and sustainable construction outcomes means projects protect workers, minimize environmental harm, conserve resources, and operate efficiently. These outputs improve social responsibility, strengthen stakeholder trust, and enhance the resilience of construction projects and the long-term reputation (Hassan, 2024; Marhavidas et al., 2018; Rahman et al., 2022). At the same time, by incorporating a culture of continuous improvement, feedback mechanisms, and technological advancements, the model ensures that safety and sustainability objectives are fulfilled in harmony. Eventually, the proposed model emphasizes that safety management is not separate from sustainability, but an essential component of it, ensuring that every sustainable construction project can also be a safe one.



**Figure 1. A Proposed Conceptual Model for Safety Management in Sustainable Construction Projects**

Despite its contributions, this research is conceptual in nature and thus subject to some limitations. It does not cover quantitative testing or empirical validation of the proposed model in real construction settings. Contextual differences (e.g., resource availability,

organizational maturity, and regulatory environments) may influence the model's applicability across various project types or regions (Gunduz & Almuajebh, 2020; Liwång, 2020). Additionally, the integration of digital tools, such as AI and IoT, although promising,

requires further assessment regarding implementation costs, data accuracy, and ethical implications (Marhavidas et al., 2018; Rahman et al., 2022).

From a practical perspective, this model provides construction policymakers, project managers, and practitioners with a guide for embedding SM into sustainable construction practices. It emphasizes the importance of continuous training, leadership commitment, and the application of data-driven safety technologies to ensure compliance and enhance decision-making (Gunduz & Almuajebh, 2020; Liwång, 2020; Secundo et al., 2020). Organizations can use this model to align their safety performance goals with sustainability initiatives, to generate safer, socially responsible, and more efficient construction outcomes.

For future academic research, empirical studies should refine and test this model using surveys, longitudinal data, or case studies from SCPs across distinct regions. Quantitative models could be used to measure relationships between SCPs' inputs, work conditions, and outcomes, while qualitative research could investigate behavioral and contextual factors influencing the integration of the three stages of this model. Yet, future studies could explore the long-term influences of technological innovation, such as AI, BIM, or IoT, on safety performance and sustainability outcomes.

## 5. Conclusion

This research has developed a proposed conceptual model that integrates safety management within sustainable construction projects through three interrelated stages: safety management inputs in SCPs, safe work conditions in SCPs, and safety management outcomes in SCPs. The proposed model illustrates how structured SM inputs (e.g., safety policies, leadership commitment, training, and the deployment of modern technologies) represent the basis for creating safe and sustainable construction projects (Fortunato et al., 2012; Hassan, 2022; Marhavidas et al., 2018; Rahman et al., 2022). When these inputs are successfully implemented, they lead to enhanced work conditions characterized by worker well-being, environmental responsibility, and operational safety (Dewlaney & Hallowell, 2012; Gunduz & Almuajebh, 2020; Liwång, 2020). Sequentially, these safe conditions produce measurable outputs, covering stronger safety culture, reduced incidents, and improved overall project performance, culminating in sustainable outcomes that balance environmental protection, social responsibility, and safety (Wiek et al., 2011; Zacchei & Molina, 2020).

However, this study is limited by its conceptual nature and absence of empirical validation. Future research should focus on empirically testing the proposed framework across different project contexts to investigate

the relationships between safety inputs, safe work conditions, and outcomes. Quantitative methods and longitudinal studies are recommended to assess the model's practical effectiveness, particularly in region-specific contexts such as the Middle East. In addition, integrating digital tools such as IoT, BIM, and AI-based systems in future investigations can provide deeper insights into enhancing safety management in sustainable construction projects.

To sum up, this research emphasizes that safety and sustainability are mutually reinforcing objectives. Achieving both safe and sustainable construction requires not only robust leadership commitment and organized processes but also a culture of innovation and continuous learning. The proposed model offers a theoretical foundation and a practical roadmap for progressing the dual goals of safety management and sustainable development in the construction industry (Marhavidas et al., 2018; Rahman et al., 2022).

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