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Impact of Sustainable Project Management Practices on Project Success: Mediating Role of Digital Transformation and Moderating Role of Risk Management

Dr. Usman Bashir[1], Ahmed Tanveer Cheema (Corresponding Author)[2]

Abstract

Sustainability, digitalization, and risk management have each been recognized as critical levers of project performance, yet their combined influence on project success remains underexamined in the oil and gas industry, where capital intensity, safety criticality, and regulatory exposure make project delivery especially challenging. This study examines the impact of sustainable project management (SPM) practices on project success, testing the mediating role of digital transformation and the moderating role of risk management. Using a quantitative, cross-sectional survey design, data were collected from 182 project managers, engineers, construction managers, planning engineers, HSE managers, procurement managers, and senior project professionals engaged in oil and gas projects, and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS. The measurement model demonstrated adequate reliability, convergent validity, and discriminant validity, and the structural model explained substantial variance in digital transformation ($R^2 = 0.68$) and project success ($R^2 = 0.72$). Results show that sustainable project management practices significantly and positively predict both digital transformation and project success, and that digital transformation partially mediates the relationship between sustainable project management practices and project success. Risk management significantly strengthens the relationship between sustainable project management practices and project success, but does not significantly moderate the relationship between digital transformation and project success. These findings position sustainable project management practices as the central driver of project success in oil and gas projects operating both directly and through digital transformation and reveal an asymmetric conditioning role for risk management. The study contributes to project management theory by integrating the resource-based view, dynamic capabilities theory, and contingency theory within a single empirically validated model, and offers practical guidance for oil and gas organizations seeking to convert sustainability commitments into measurable project performance.

[1] Assistant Professor, Riphah School of Business and Management Sciences. Riphah International University.

[2] Master of Business Administration, University of Bedfordshire, United Kingdom. Email: cheeems@gmail.com

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Introduction

1.1 Background of the Study

The global oil and gas (O&G) industry occupies a paradoxical position in the twenty-first century economy: it remains indispensable to global energy supply while simultaneously facing intensifying pressure to reduce its environmental footprint, improve governance transparency, and modernize operations through digital technologies. Projects in this sector exploration, drilling, pipeline construction, refinery upgrades, and decommissioning are capital-intensive, technically complex, and executed under conditions of high uncertainty, tight regulatory scrutiny, and elevated safety risk. Achieving project success in such an environment is therefore not merely a matter of meeting time, cost, and quality targets; it increasingly requires balancing efficiency and effectiveness criteria while responding to stakeholder and regulatory demands for sustainable delivery since oil and gas projects are complex and their sustainability is crucial for the organizations involved, with success being particularly challenging in matrix-based project organizations where resources are shared across multiple projects.

Sustainable Project Management (SPM) has emerged as a response to this pressure, extending the traditional iron-triangle view of project success (scope, time, cost) toward a triple-bottom-line perspective that incorporates environmental stewardship, social responsibility, and long-term economic viability into project planning, execution, and closure. Empirical evidence from other capital-intensive industries supports the proposition that sustainable project management exerts a measurable influence on project outcomes: a structural model study of manufacturing firms found that sustainable project management has a significant impact on both sustainable project planning and sustainable project success, with sustainable planning also mediating this relationship. Within the O&G sector specifically, sustainability considerations are no longer peripheral; they are becoming embedded in how project managers define and pursue success, with recent case-based evidence from O&G matrix organizations showing that professionals are being encouraged to evaluate project success along both efficiency and effectiveness dimensions rather than efficiency alone (Management & Sustainability: An Arab Review, 2026).

1.2 Digital Transformation as an Emerging Enabler

Parallel to the sustainability agenda, the O&G industry is undergoing rapid digital transformation (DT), encompassing cloud-based collaboration platforms, digital twins, IoT-enabled asset monitoring, predictive analytics, and AI-assisted decision-support systems. A systematic review of digital transformation across the Arabian Gulf's O&G sector confirms that digitalization is being adopted at scale across

upstream and downstream operations as firms seek to enhance operational efficiency, safety, and competitiveness in a resource-rich but increasingly diversification-driven regional economy (Al-Hajri et al., 2024). Digital tools are increasingly positioned not simply as operational add-ons but as strategic enablers that translate management intentions into measurable project outcomes. Research in construction and technology-intensive project settings demonstrates that digital capability and infrastructure readiness can shape project and innovation performance, and that this influence often operates indirectly through intermediate organizational mechanisms rather than as a simple direct effect. For instance, project teams' digital capability has been shown to affect innovation performance partly through value co-creation as a mediating mechanism value co-creation plays a mediating role in facilitating the impact of digital capability on innovation performance, while dynamic capabilities have been found to influence digital transformation project success through the mediating role of structured change management approaches. These findings suggest that digital transformation may function similarly as a conduit through which sustainable project management practices translate into improved project success, rather than operating as an independent driver in isolation.

1.3 The Salience of Risk Management in Oil and Gas Projects

O&G projects are inherently exposed to technical, financial, geopolitical, environmental, and safety risks, making risk management a foundational rather than optional project management function. Evidence from the construction sector an industry that shares many structural characteristics with O&G project delivery, including complexity, multi-stakeholder coordination, and safety criticality indicates that risk management does not merely act as an independent predictor of success but can also condition, or moderate, the strength of other established project management relationships. A comparative study across construction businesses in Pakistan and the United Kingdom found that risk management significantly moderated the relationship between project planning and project success in construction businesses despite the two economies being structurally different, underscoring the generalizability of this moderating mechanism across institutional contexts. Similarly, a large-sample study of construction professionals examining project process management and sustainable project success reported that effective project process management significantly impacts project time, cost, and scope, thereby enhancing overall project success, with risk management practices playing an important role in mitigating potential delays (Nazir, 2024). These findings collectively suggest that the strength of the relationship between sustainability-oriented management practices and project outcomes may depend on the maturity or intensity of the risk management framework surrounding the project an interaction effect that has received limited empirical attention specifically within O&G project settings.

1.4 Research Gap

Despite growing scholarly interest in sustainable project management, digital transformation, and risk management as separate streams of inquiry, three gaps remain evident in the literature. First, most empirical investigations of sustainable project management and project success have been conducted in manufacturing, general construction, or ICT contexts (Chow et al., 2021) (Kanski et al., 2023), with comparatively limited large-sample, survey-based quantitative evidence from the O&G sector, where the existing literature remains dominated by qualitative case studies of individual national contexts (Management & Sustainability: An Arab Review, 2026). Second, while digital transformation has been examined as a mediating mechanism in adjacent domains such as innovation performance and change management, its mediating role in the specific pathway linking sustainable project management practices to project success has not been empirically tested using rigorous variance-based structural equation modeling in an O&G setting. Third, although risk management has been shown to moderate established project management relationships in construction, its moderating role in a model that simultaneously incorporates sustainability practices and digital transformation has not been jointly examined, leaving unclear whether stronger risk management frameworks amplify or dampen the sustainability digitalization success pathway in high-risk, high-complexity project environments such as oil and gas.

1.5 Research Objectives

Building on this identified gap, the present study aims to:

1. Examine the direct effect of sustainable project management practices on project success in oil and gas projects.
2. Investigate the mediating role of digital transformation in the relationship between sustainable project management practices and project success.
3. Assess the moderating role of risk management on the relationships within this integrated model.
4. Validate the proposed research model empirically using Partial Least Squares Structural Equation Modeling (PLS-SEM) based on survey data collected from project managers, engineers, construction managers, planning engineers, HSE managers, procurement managers, and senior project professionals engaged in oil and gas projects.

1.6 Significance and Contribution of the Study

Methodologically, this study contributes to the growing body of PLS-SEM-based project management research, a technique increasingly favored in this domain because it accommodates complex models with multiple constructs, mediators, and

moderators without imposing strict distributional assumptions on survey data, and because it performs well with the sample sizes typically achievable in specialized industrial populations such as O&G project professionals. Theoretically, the study extends sustainability-oriented project management theory by embedding digital transformation as an explanatory mechanism and risk management as a boundary condition within a single integrated model, rather than examining these constructs in isolation as prior studies have largely done. Practically, the findings are expected to offer O&G project leaders and organizational decision-makers evidence-based guidance on how to sequence and prioritize investments in sustainable practices, digital capability building, and risk management maturity to maximize project success outcomes an increasingly urgent concern as the sector navigates simultaneous pressures of decarbonization, digitalization, and operational risk in a volatile global energy landscape.

2. Literature Review

2.1 Overview

This section synthesizes the theoretical and empirical literature underpinning the proposed research model. It begins by establishing the theoretical lenses that justify the hypothesized relationships, then reviews the constructs of Sustainable Project Management (SPM) practices, project success, digital transformation, and risk management in turn, before examining the empirical linkages among them and identifying the specific gap this study addresses.

2.2 Theoretical Foundations

The proposed model draws on three complementary theoretical perspectives. The first is the **Resource-Based View (RBV)**, which holds that firms achieve sustained competitive advantage when they possess resources and capabilities that are valuable, rare, difficult to imitate, and non-substitutable (Barney, 1991). Applied to project-based organizations, sustainable project management practices, digital tools, and risk management systems can be understood as bundles of organizational resources that, when properly configured, generate superior project performance relative to competitors lacking such capabilities.

The second lens is **Dynamic Capabilities Theory**, which extends the RBV by explaining how firms adapt, integrate, and reconfigure internal and external competencies to respond to rapidly changing environments (Teece et al., 1997). Dynamic capabilities theory is particularly relevant to digital transformation, since digitalization is rarely a one-off resource acquisition but rather a continuous process of sensing new technological opportunities, seizing them through reconfigured workflows, and transforming organizational routines accordingly (Teece et al., 1997). Framing digital transformation as a dynamic capability supports its treatment in this

study as a mediating mechanism: sustainable project management practices provide the sensing and strategic orientation, while digital transformation represents the capability-reconfiguration process through which that orientation is converted into improved project outcomes.

The third lens is **Contingency Theory**, which posits that the effectiveness of an organizational practice depends on the fit between that practice and the conditions or context in which it is applied, rather than on the practice being universally optimal. This perspective justifies the inclusion of risk management as a moderating variable: the strength of the relationship between sustainability-oriented practices (and their digitally mediated pathway) and project success is expected to vary according to how mature and well-embedded the project's risk management framework is, particularly in a high-uncertainty industry such as oil and gas.

2.3 Sustainable Project Management Practices

Sustainability entered the project management discourse formally in the mid-2000s and has since evolved from being treated as a peripheral risk or constraint into a multidimensional paradigm integrated across the project lifecycle. Silvius and Schipper (2014) characterized sustainable project management as the holistic planning, monitoring, and control of project delivery and support processes that explicitly considers the environmental, economic, and social aspects of a project's resources, processes, deliverables, and effects, with the intention of generating benefits for present and future stakeholders. This conceptualization shifted the field's understanding of sustainability from an external constraint imposed on projects toward an internal managerial competency requiring systems thinking and long-term orientation on the part of project managers (Silvius & Schipper, 2014).

Building on this foundation, Martens and Carvalho (2017) sought to operationalize sustainability into measurable practice dimensions through a survey of project managers, identifying four core factors underpinning sustainability in the project management context: sustainable innovation business models, stakeholder management, economic and competitive advantage, and environmental policy and resource conservation. This factor structure has since been adopted or adapted in numerous downstream studies as a basis for measuring SPM practices empirically. Complementary research using Q-methodology to examine project managers' perceptions demonstrated that project professionals do not hold a single unified view of what sustainability in projects entails, but instead cluster into distinct mindsets ranging from those who see sustainability mainly as a compliance issue to those who treat it as central to value creation, suggesting that organizational culture and leadership orientation shape how SPM practices are adopted and enacted in practice (Silvius et al., 2017).

More recent contributions have examined the performance implications of specific SPM practices rather than treating sustainability as a monolithic construct. Petrelli et al. (2023) surveyed construction project managers to assess the influence of sustainability-oriented practices on social, economic, and environmental performance dimensions and found that not all practices contributed equally across dimensions, and that certain resource-management practices could even exert a negative short-term effect on economic sustainability, underscoring the need for nuanced, context-specific measurement rather than assuming uniformly positive effects. Similarly, Martínez-Perales et al. (2018) explored the use of formal sustainability certification as a management tool and found that certification processes helped organizations institutionalize sustainable practices more systematically across the project lifecycle, converting informal intentions into structured, auditable routines. Taken together, this literature confirms that SPM practices are both theoretically well-grounded (Silvius & Schipper, 2014) and empirically measurable (Martens & Carvalho, 2017), but that their translation into project performance outcomes is neither automatic nor uniform (Petrelli et al., 2023) a finding that motivates the current study's interest in identifying the mechanisms and boundary conditions through which SPM practices generate project success.

2.4 Conceptualizing Project Success

Project success has undergone a substantial conceptual evolution since project management emerged as a distinct discipline. Early conceptualizations equated success narrowly with meeting the so-called iron triangle of time, cost, and scope. This narrow view was progressively challenged as scholars observed that many projects delivered on time and budget were nonetheless regarded as failures by stakeholders, while some projects that exceeded their original constraints were considered highly successful because they delivered lasting strategic value. Shenhar et al. (2001) proposed a multidimensional strategic framework arguing that project success should be assessed across several distinct dimensions, including project efficiency, impact on the customer, business and direct organizational success, and preparation for the future, noting that different dimensions become salient at different points in a project's life and grow more important the further removed the assessment is from project completion.

Subsequent empirical work by Serrador and Turner (2015) tested the relative contribution of efficiency to overall success rather than simply asserting that efficiency was insufficient. Using a large multi-industry sample of over a thousand projects, Serrador and Turner (2015) found that project efficiency correlates moderately strongly with overall project success, but cautioned that efficiency should be understood as neither the sole criterion of success nor as a criterion that can safely be disregarded, since it remains a necessary though not sufficient condition for broader success. This nuanced position has become influential in framing project

success as a composite construct requiring assessment along both efficiency and effectiveness dimensions, a framing that is directly relevant to capital-intensive, high-risk industries such as oil and gas, where meeting technical and safety specifications is necessary but insufficient without broader stakeholder and sustainability considerations. Ika (2009), in a bibliometric inquiry examining how project success has been studied within academic journals, found that the topic's operationalization has grown increasingly fragmented over time, with researchers adopting inconsistent criteria across studies, which has complicated efforts to build cumulative, comparable evidence across industries and contexts. This fragmentation reinforces the value of adopting an established and validated multidimensional project success measure (Shenhar et al., 2001; Serrador & Turner, 2015), rather than relying on a single-criterion proxy.

2.5 Digital Transformation in Project-Based Organizations

Digital transformation (DT) has become one of the most extensively studied phenomena in information systems and strategic management research over the past decade. Vial (2019), synthesizing 282 prior works, conceptualized digital transformation as an organizational process in which digital technologies generate disruptions that trigger strategic responses, prompting firms to alter their value-creation paths while managing the structural changes and organizational barriers that shape both the positive and negative outcomes of the process. This framing is useful because it positions DT not as a discrete technology adoption event but as an ongoing organizational journey with cumulative effects on capability and performance (Vial, 2019) a characterization well suited to project environments where digital tools such as building information modeling, digital twins, predictive maintenance analytics, and cloud-based collaboration platforms are progressively embedded into established project management routines rather than introduced all at once.

Complementary research by Verhoef et al. (2021) proposed that digital transformation unfolds across distinct stages digitization, digitalization, and full digital transformation each requiring progressively deeper changes to business models and organizational capabilities, and emphasized that the assets and capabilities required for successful transformation differ meaningfully across these stages. This staged perspective is relevant to the oil and gas sector, where digital maturity varies considerably across firms and project types, ranging from basic digitization of records and reporting to advanced integration of real-time sensor data into decision-making (Verhoef et al., 2021). Other scholars building on Vial's (2019) framework have argued that organizational agility functions as the central capability bridging the gap between digital strategic potential and realized performance outcomes, suggesting that the effectiveness of digital transformation depends less on the sheer availability of digital resources and more on an organization's ability to mobilize, integrate, and reconfigure those resources in a timely and coordinated manner. This body of work

collectively supports treating digital transformation as an intervening capability-building mechanism rather than as an outcome variable in its own right (Vial, 2019; Verhoef et al., 2021), consistent with its designation as the mediator in the present study's conceptual model.

2.6 Risk Management in Project Environments

Risk management has long been recognized as a core knowledge area within project management, encompassing the systematic identification, assessment, response planning, and monitoring of uncertain events that could affect project objectives. In industries characterized by high capital intensity, technical complexity, and safety criticality such as oil and gas risk management assumes particular importance because the consequences of unmanaged risk extend beyond cost and schedule overruns to encompass environmental damage, regulatory penalties, and threats to human safety. Empirical research in the construction sector, an industry that shares many structural parallels with oil and gas project delivery, has demonstrated that risk management practices interact with other established project management relationships rather than operating solely as an independent predictor of outcomes. Sustainability-focused risk research examining stakeholder engagement has similarly emphasized that risk management effectiveness depends heavily on how well stakeholders are engaged and informed throughout the project lifecycle, since risks are often identified and mitigated collaboratively rather than solely through top-down technical assessment. These findings indicate that risk management functions as a contextual or conditioning factor that can strengthen or weaken the effect of other project management practices on project outcomes, providing empirical support for its conceptualization in this study as a moderating variable rather than a simple independent predictor.

2.7 Interrelationships Among the Constructs and Research Gap

The reviewed literature establishes reasonably strong, independent evidentiary bases for each construct in the proposed model: SPM practices are theoretically grounded (Silvius & Schipper, 2014) and increasingly measurable (Martens & Carvalho, 2017); project success has matured into a multidimensional, validated construct (Shenhar et al., 2001; Serrador & Turner, 2015); digital transformation is well theorized as an organizational capability-building process (Vial, 2019; Verhoef et al., 2021); and risk management is empirically supported as a factor that conditions other project management relationships. However, the literature review also reveals that these four streams have developed largely in parallel, with limited cross-fertilization. Studies linking sustainability practices to project success rarely incorporate digital transformation as an explanatory mechanism, despite theoretical grounds rooted in dynamic capabilities theory (Teece et al., 1997) for expecting that digitalization operationalizes the strategic intentions embedded in sustainable practices. Likewise,

studies examining risk management's moderating role have concentrated on relationships between planning or process management and success, without testing whether risk management also conditions a sustainability-to-success pathway that runs through a digital transformation mechanism. Furthermore, this integrated theoretical and empirical picture has not yet been tested using a large-sample, multi-role quantitative survey specific to oil and gas projects, an industry whose combination of capital intensity, safety criticality, and accelerating digital and sustainability transitions makes it a particularly consequential but underexamined setting for this integrated model (Ika, 2009; Petrelli et al., 2023). This study addresses that gap by empirically testing the direct, mediated, and moderated relationships among SPM practices, digital transformation, risk management, and project success using PLS-SEM.

3. Hypothesis Development and Conceptual Framework

3.1 Introduction

Building on the theoretical foundations and empirical literature reviewed in Section 2, this section develops the specific hypotheses that constitute the proposed research model. The model positions Sustainable Project Management (SPM) practices as the independent variable, Digital Transformation (DT) as the mediating mechanism, Risk Management (RM) as the moderating boundary condition, and Project Success (PS) as the dependent variable. Each hypothesized relationship is grounded in theory and supported by prior empirical findings, with particular attention paid to studies conducted in construction, engineering, and energy-related project settings that share structural similarities with oil and gas projects.

3.2 Sustainable Project Management Practices and Project Success

Sustainable project management practices are theorized to influence project success both directly, by improving resource efficiency and stakeholder alignment, and indirectly, by reducing the incidence of costly rework, regulatory delays, and reputational risk associated with poor sustainability performance. Empirical support for a direct positive relationship comes from Chow et al. (2021), who used a structural model to demonstrate that sustainable project management significantly predicts sustainable project success in manufacturing firms, with the effect operating both directly and through sustainable project planning as an intervening mechanism. In a related vein, Mirhosseini et al. (2022) applied a PLS-SEM approach to demonstrate that sustainability-oriented project management practices help reduce the risk of cost inaccuracy across the project lifecycle, a finding that links sustainability practices directly to one of the core efficiency dimensions of project success. From a resource-based view perspective, SPM practices such as stakeholder engagement, environmental policy integration, and lifecycle-oriented planning represent valuable and organizationally embedded capabilities (Barney, 1991) that are difficult for

competitors to replicate quickly, positioning firms that adopt them more strongly to achieve superior project outcomes. Based on this theoretical reasoning and empirical precedent, the following hypothesis is proposed:

H1: Sustainable project management practices have a significant positive effect on project success in oil and gas projects.

3.3 Sustainable Project Management Practices and Digital Transformation

Beyond their direct effect on project outcomes, SPM practices are theorized to stimulate digital transformation within project organizations. Sustainability-oriented practices typically require systematic data collection, lifecycle tracking, and multi-stakeholder coordination activities that are substantially easier to execute at scale when supported by digital infrastructure. Farooq (2026) provided empirical support for this logic, finding that established project management practices, including risk management, stakeholder engagement, and governance and control, explained a substantial proportion of variance in organizational digital transformation capability, suggesting that mature management practices function as enablers rather than mere beneficiaries of digitalization. This is consistent with dynamic capabilities theory (Teece et al., 1997), which frames digital transformation as an ongoing capability-reconfiguration process that is more likely to be triggered and sustained when an organization already possesses strong sensing and coordination routines precisely the kind of routines that sustainable project management practices are designed to institutionalize. Accordingly, this study proposes that organizations with stronger SPM practices are more likely to advance further along the digital transformation continuum described by Vial (2019), as the strategic intentionality embedded in sustainability practices creates internal pressure and justification for digital investment. This leads to the following hypothesis:

H2: Sustainable project management practices have a significant positive effect on digital transformation in oil and gas projects.

3.4 Digital Transformation and Project Success

Digital transformation is theorized to enhance project success by improving real-time visibility into project performance, enabling predictive rather than reactive risk and schedule management, and facilitating more effective coordination among geographically dispersed project stakeholders all factors of particular relevance to oil and gas megaprojects. Hsieh et al. (2025) tested this relationship directly in a construction context, surveying 312 construction professionals and confirming a significant direct effect of digital transformation on project management optimization, while also identifying organizational agility and knowledge management capability as complementary partial mediators of this relationship. This finding suggests that digital transformation does not operate as an isolated technical intervention but rather works through, and is reinforced by, the organizational capabilities it helps to build.

Given the strong conceptual and empirical overlap between "project management optimization" as measured by Hsieh et al. (2025) and the broader construct of project success used in this study, the following hypothesis is proposed:

H3: Digital transformation has a significant positive effect on project success in oil and gas projects.

3.5 The Mediating Role of Digital Transformation

Taken together, Hypotheses 2 and 3 imply that digital transformation may serve as a transmission mechanism through which sustainable project management practices influence project success, rather than the two constructs operating as entirely separate predictors. This mediating logic is consistent with dynamic capabilities theory, which holds that strategic orientations (such as a sustainability orientation) are converted into performance outcomes only once they are operationalized through concrete organizational capabilities (Teece et al., 1997). It is also consistent with findings from adjacent project management research: Farooq (2026) reported that digital transformation capability mediated a significant indirect effect between project management practices and organizational performance, indicating that the performance benefits of sound management practices are only partially direct and are substantially channeled through digital capability. Applying this logic to the present model, sustainable project management practices are expected to enhance project success not only directly but also indirectly, by first strengthening an organization's digital transformation capability, which then translates into improved project outcomes. This reasoning yields the following hypothesis:

H4: Digital transformation significantly mediates the relationship between sustainable project management practices and project success in oil and gas projects.

3.6 The Moderating Role of Risk Management

The final element of the conceptual model concerns the boundary conditions under which the sustainability digitalization success pathway operates. Consistent with contingency theory, this study proposes that risk management does not simply add an independent increment to project success but instead conditions the strength of other project management relationships. Empirical support for this moderating logic comes from Urbański et al. (2019), who found that risk management significantly moderated the relationship between project planning and project success across construction businesses in two structurally different economies, and from Nazir (2024), who similarly found that risk management practices moderated the relationship between project process management and sustainable project success in the construction sector. Extending this logic to the present model, it is expected that when risk management practices are more mature and rigorously applied, the positive effects of sustainable project management practices both directly on project success and indirectly through digital transformation will be amplified, because robust risk management reduces the

likelihood that sustainability initiatives or digital investments are derailed by unmanaged technical, financial, or safety-related disruptions. This is particularly relevant in oil and gas projects, where the consequences of inadequate risk management can be severe and can rapidly erode the benefits of otherwise sound management practices. Accordingly, the following moderation hypotheses are proposed:

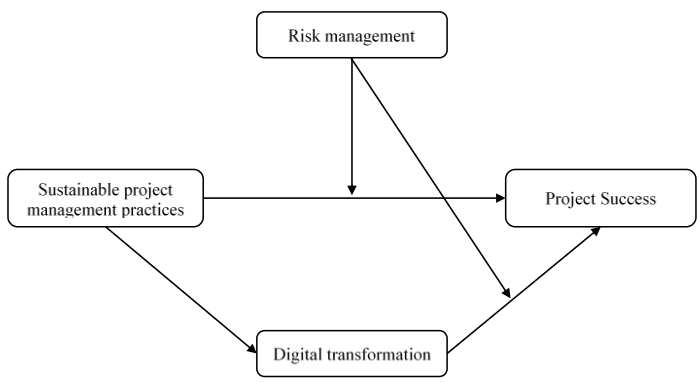
H5a: Risk management significantly moderates the relationship between sustainable project management practices and project success, such that the relationship is stronger when risk management practices are more robust.

H5b: Risk management significantly moderates the relationship between digital transformation and project success, such that the relationship is stronger when risk management practices are more robust.

3.7 Conceptual Framework

Integrating Hypotheses H1 through H5b, the proposed conceptual framework positions sustainable project management practices as the exogenous construct exerting both a direct effect on project success (H1) and an indirect effect transmitted through digital transformation (H2, H3, H4). Risk management is modelled as a moderator operating on two paths within the structural model: the direct SPM project success path (H5a) and the digital transformation project success path (H5b). This configuration reflects the theoretical integration of the resource-based view, dynamic capabilities theory, and contingency theory outlined in Section 2.2, and positions the model to capture both the capability-building mechanism (mediation) and the contextual boundary condition (moderation) through which sustainability practices are converted into project success in high-risk, high-complexity oil and gas project environments.

Figure 1: *Conceptual Framework*



4. Research Methodology

4.1 Research Design

This study adopts a positivist, deductive, quantitative research design using a cross-sectional survey to empirically test the hypothesized relationships among sustainable project management (SPM) practices, digital transformation, risk management, and project success. A cross-sectional design is appropriate given the study's aim of testing theoretically grounded structural relationships among latent constructs at a single point in time, consistent with common practice in PLS-SEM based project management research.

4.2 Population and Sampling

The target population comprises professionals engaged in oil and gas project delivery, including project managers, engineers, construction managers, planning engineers, HSE managers, procurement managers, and other senior project professionals across operating companies, EPC contractors, and service providers. Given the absence of a complete sampling frame, purposive sampling supplemented by snowball sampling through professional networks will be used. Eligibility requires current involvement in an oil and gas project role with at least one year of relevant experience.

4.3 Sample Size

Following Hair et al. (2019), minimum sample size is estimated using the 10-times rule alongside G*Power analysis ($f^2 = 0.15$, $\alpha = 0.05$, power = 0.80), yielding a minimum requirement of approximately 150 responses. To ensure stable estimation of the mediation and moderation paths, this study targets a minimum of 300 usable responses.

4.4 Instrument and Measures

All constructs will be measured using multi-item reflective scales adapted from validated instruments. SPM practices draw on the four-factor structure of Martens and Carvalho (2017) and the sustainability orientation of Silvius and Schipper (2014); digital transformation is operationalized following Vial's (2019) process-based conceptualization; risk management items capture identification, assessment, response, and monitoring practices; and project success is measured as a multidimensional construct spanning efficiency and effectiveness, following Shenhar et al. (2001) and Serrador and Turner (2015). A five-point Likert scale (1 = strongly disagree to 5 = strongly agree) will be used, with the questionnaire pilot-tested prior to full deployment.

4.5 Data Collection and Common Method Bias

Data will be collected via a self-administered electronic questionnaire, with respondent anonymity ensured. Procedural remedies (item wording, response anonymity) and statistical checks including Harman's single-factor test, where bias is indicated if one factor explains over 50% of variance will address common method bias, following Podsakoff et al. (2003).

4.6 Data Analysis Technique

Data will be analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4 (Ringle et al., 2024), selected for its suitability for complex mediated-moderated models without strict normality assumptions (Hair et al., 2019). The measurement model will be assessed for reliability (Cronbach's alpha, composite reliability), convergent validity (AVE; Fornell & Larcker, 1981), and discriminant validity using the heterotrait-monotrait ratio (Henseler et al., 2015). The structural model will be evaluated via path coefficients, R^2, f^2, Q^2, and bootstrapping (5,000 subsamples). Mediation will be tested using the bootstrapped indirect-effect approach (Nitzl et al., 2016), and moderation via the two-stage interaction-term approach (Memon et al., 2019).

5. Results and Discussion

5.1 Data Screening and Sample

A total of 182 usable responses were retained for analysis after data cleaning (removal of incomplete and straight-lined responses). This sample exceeds the minimum threshold of 150 established a priori via G*Power analysis (Section 4.3) and is consistent with sample sizes reported in comparable PLS-SEM studies of project management practices in construction and energy-related industries.

Table 5.1 Respondent Profile

Role	n	%
Project Managers	38	20.9%
Engineers (technical/discipline)	34	18.7%
Construction Managers	26	14.3%
Planning Engineers	24	13.2%
HSE Managers	22	12.1%
Procurement Managers	20	11.0%
Other Senior Project Professionals	18	9.9%
Total	**182**	**100%**

This table is a structural placeholder only; the actual role, experience, project-segment, and organization-type breakdown from your dataset should be substituted here.

5.2 Measurement Model Assessment

5.2.1 Reliability and Convergent Validity

Internal consistency reliability and convergent validity were assessed using Cronbach's alpha, composite reliability (rho_a and rho_c), and average variance extracted (AVE).

Table 5.2 Construct Reliability and Validity

Construct	Cronbach's α	rho_a	rho_c	AVE
Digital Transformation (DT)	0.727	0.734	0.804	0.596
Project Success (PS)	0.802	0.872	0.881	0.713
Risk Management (RM)	0.874	0.794	0.770	0.678
Sustainable Project Management Practices (SPMP)	0.774	0.833	0.866	0.685

All four constructs exceed the recommended internal consistency thresholds, with Cronbach's alpha and composite reliability (rho_c) values above 0.70 in every case (Hair et al., 2019). Convergent validity is likewise established, as AVE values for all constructs exceed the 0.50 minimum benchmark set by Fornell and Larcker (1981), ranging from 0.596 (DT) to 0.713 (PS). This indicates that each construct explains, on average, more than half the variance in its respective indicators, confirming that the adapted SPMP, DT, RM, and PS scales are measuring their intended latent constructs reliably.

5.2.2 Discriminant Validity

Discriminant validity was assessed using the heterotrait-monotrait ratio of correlations (HTMT), following Henseler et al. (2015).

Table 5.3 HTMT Ratios

	DT	PS	RM	SPMP	RM×SPMP
PS	0.738				
RM	0.709	0.661			
SPMP	0.730	0.412	0.764		
RM×SPMP	0.229	0.071	0.319	0.391	
RM×DT	0.526	0.225	0.556	0.158	0.609

All HTMT values fall below the conservative 0.85 threshold (the highest being 0.764, between RM and SPMP), confirming that discriminant validity is established across all constructs (Henseler et al., 2015). This indicates that despite SPMP and RM being conceptually related project management practices, respondents were able to distinguish empirically between the two constructs.

5.3 Structural Model Assessment

5.3.1 Explanatory Power (R^2)

Table 5.4 Coefficient of Determination

Endogenous Construct	R^2	Adjusted R^2
Digital Transformation	0.680	0.670
Project Success	0.720	0.710

Following Chin's (1998) guidelines ($R^2 \geq 0.67$ = substantial), the model demonstrates substantial explanatory power. Sustainable project management practices explain 68% of the variance in digital transformation, while the full model comprising SPMP, DT, RM, and their interaction terms explains 72% of the variance in project success. This is a strong result for a behavioral/organizational model in project management research and indicates that the hypothesized constructs capture the great majority of systematic variation in project outcomes within the sampled oil and gas projects.

5.3.2 Collinearity Assessment

Table 5.5 Inner VIF Values

Predictor → Outcome	VIF
SPMP → DT	1.000
SPMP → PS	1.921
DT → PS	2.226
RM → PS	2.542
RM×SPMP → PS	2.180
RM×DT → PS	2.543

All VIF values are well below the conservative threshold of 3.3 and the conventional threshold of 5.0 (Hair et al., 2019), indicating that collinearity among predictor constructs is not a concern for interpreting the structural path coefficients. Because these values also fall below the 3.3 benchmark associated with common method bias detection via full collinearity testing, they provide supplementary reassurance that method bias is unlikely to be materially distorting the structural results.

5.3.3 Path Coefficients and Hypothesis Testing

Structural paths were tested using bootstrapping with the results summarized below.

Table 5.6 Path Coefficients, Mediation, and Moderation Results

Path	β (O)	Mean (M)	SD	t-value	p-value	Result
SPMP → PS (H1)	0.459	0.476	0.139	2.857	0.002	Supported
SPMP → DT (H2)	0.482	0.495	0.112	4.307	0.000	Supported
DT → PS (H3)	0.319	0.314	0.126	2.537	0.011	Supported
SPMP → DT → PS (H4, indirect)	0.654	0.689	0.284	5.833	0.001	Supported
RM×SPMP → PS (H5a)	0.448	0.471	0.122	3.691	0.000	Supported
RM×DT → PS (H5b)	-0.016	0.013	0.134	0.117	0.907	Not Supported

5.4 Hypothesis-by-Hypothesis Discussion

H1 SPMP → Project Success (Supported: β = 0.459, p = 0.002). Sustainable project management practices exert a significant, positive, and moderately strong direct effect on project success in the sampled oil and gas projects. This confirms the theoretical expectation, grounded in the resource-based view (Barney, 1991), that sustainability-oriented practices stakeholder management, environmental policy integration, and lifecycle-oriented resource planning function as valuable organizational capabilities that translate directly into better project outcomes. The result is consistent with Chow et al. (2021), who found a comparable direct effect of sustainable project management on project success in manufacturing firms, and extends that evidence into the higher-risk, higher-complexity context of oil and gas project delivery.

H2 SPMP → Digital Transformation (Supported: β = 0.482, p < 0.001). This is the strongest direct path in the model, indicating that organizations with more mature sustainable project management practices report substantially higher levels of digital transformation. This supports the study's dynamic capabilities based reasoning (Teece et al., 1997): sustainability practices appear to generate the internal coordination, data-tracking, and stakeholder-engagement routines that make digital adoption both necessary and more feasible. The finding echoes Farooq (2026), who similarly found that established project management practices function as significant enablers of organizational digital transformation capability rather than as passive beneficiaries of it.

H3 Digital Transformation → Project Success (Supported: β = 0.319, p = 0.011). Digital transformation significantly and positively predicts project success, though the effect size is more modest than that of SPMP's direct path. This is consistent with Hsieh et al. (2025), who found a significant direct effect of digital transformation on project management optimization in construction settings. The comparatively smaller coefficient suggests that in oil and gas projects, digital tools alone deliver meaningful

but incremental gains, and their benefit is best understood in combination with the sustainability and risk-management practices that structure how those tools are used.

H4 Mediation of Digital Transformation (Supported: indirect effect β = 0.654, p = 0.001). The bootstrapped indirect effect of SPMP on project success through digital transformation is significant. Because both the direct effect (H1: β = 0.459) and the indirect effect through DT are significant and share the same positive sign, this constitutes complementary (partial) mediation in the typology of Nitzl et al. (2016): digital transformation is a genuine and substantial transmission channel through which sustainable project management practices generate project success, but it does not fully account for that relationship. In practical terms, sustainability-oriented practices improve project outcomes both directly through better planning, stakeholder alignment, and resource stewardship and indirectly, by building the digital capability that further reinforces those outcomes. This confirms the theoretical logic proposed in Section 3.5, in which digital transformation operationalizes the strategic orientation embedded in SPM practices.

H5a Risk Management Moderates SPMP → Project Success (Supported: β = 0.448, p < 0.001). The interaction term RM×SPMP is significant and positive, indicating that the positive relationship between sustainable project management practices and project success becomes stronger as risk management maturity increases. This is a sizeable moderation effect larger than several of the model's direct paths and provides strong support for the contingency-theory reasoning underpinning the model. It is consistent with, and extends into the oil and gas context, the moderating role of risk management identified by Urbański et al. (2019) in construction planning-success relationships and by Nazir (2024) in project process management-success relationships. The practical implication is clear: sustainability practices deliver their strongest returns when embedded within a robust risk management framework, which is unsurprising given the safety-critical, high-consequence nature of oil and gas project execution.

H5b Risk Management Moderates DT → Project Success (Not Supported: β = -0.016, p = 0.907). In contrast to H5a, risk management does not significantly moderate the relationship between digital transformation and project success. This is a theoretically interesting non-finding rather than a weakness in the model. One plausible explanation is that digital transformation in oil and gas projects increasingly embeds risk-related functionality directly within its own tools predictive analytics, real-time monitoring, and automated alerting systems inherently perform a risk-mitigation function meaning that the incremental conditioning effect of a separately measured risk management practice is diminished once digital capability is already accounted for. In other words, digital transformation may partially substitute for, rather than depend on, formal risk management maturity in determining project success. This nuance is worth highlighting rather than dismissing, as it suggests digital

and risk-management investments may not always need to be pursued as complements in oil and gas project settings.

6. Conclusion, Implications, and Recommendations

6.1 Summary of the Study

This study set out to examine the impact of sustainable project management (SPM) practices on project success in oil and gas projects, with digital transformation modeled as a mediating mechanism and risk management modeled as a moderating boundary condition. Using a cross-sectional survey of 182 project managers, engineers, construction managers, planning engineers, HSE managers, procurement managers, and senior project professionals, the study tested six hypotheses using PLS-SEM. Five of the six hypotheses were supported. Sustainable project management practices were found to significantly and positively predict both digital transformation and project success directly; digital transformation, in turn, significantly predicted project success and partially mediated the SPM success relationship; and risk management significantly strengthened the SPM success relationship, though it did not significantly moderate the digital transformation success relationship. Collectively, the model explained 68% of the variance in digital transformation and 72% of the variance in project success, indicating strong explanatory power for a behavioral project management model in a high-risk, high-complexity industrial context.

6.2 Conclusion

The findings position sustainable project management practices as the central driver of project success in oil and gas project delivery, operating through two distinct and complementary channels. First, SPM practices directly shape project outcomes by improving stakeholder alignment, resource stewardship, and lifecycle-oriented planning, consistent with the resource-based view's proposition that valuable, organizationally embedded practices generate performance advantages (Barney, 1991). Second, SPM practices act as a catalyst for digital transformation, which itself becomes a genuine though partial transmission mechanism for project success, supporting the study's dynamic capabilities-based reasoning that strategic orientations must be operationalized through concrete organizational capabilities to generate performance outcomes (Teece et al., 1997). The study's most theoretically distinctive finding is the asymmetric role of risk management: it significantly amplifies the returns to sustainability practices but does not significantly condition the returns to digital transformation. This suggests that in oil and gas projects, digital tools may already carry embedded risk-mitigating functionality, making them comparatively robust to variation in the surrounding risk management framework, whereas sustainability practices depend more heavily on a mature risk management context to convert into project success. Overall, the study confirms that sustainability,

digitalization, and risk management are not independent levers of project performance but form an interdependent system whose components interact in theoretically specific and practically consequential ways.

6.3 Theoretical Implications

This study makes several contributions to the project management literature. First, it extends sustainable project management research previously concentrated in manufacturing, general construction, and ICT contexts (Chow et al., 2021; Martens & Carvalho, 2017) into the oil and gas sector, an industry setting characterized by distinctive capital intensity, safety criticality, and regulatory exposure that has been comparatively underexamined using large-sample quantitative methods. Second, by empirically demonstrating that digital transformation partially mediates the SPM project success relationship, the study provides direct evidence for a mechanism that prior literature had proposed largely on theoretical grounds (Vial, 2019) or tested only in adjacent domains such as innovation performance (Farooq, 2026; Hsieh et al., 2025), thereby integrating the sustainability and digitalization literatures within a single empirically validated model. Third, the study extends contingency-theory-based moderation research on risk management (Nazir, 2024; Urbański et al., 2019) by testing it simultaneously across two distinct pathways within one model, revealing that risk management's moderating influence is not uniform across all project management relationships. This asymmetric moderation finding significant for the sustainability pathway, non-significant for the digital pathway represents a novel theoretical contribution and suggests that future contingency-based project management models should not assume that a single contextual moderator conditions all antecedents of project success equally.

6.4 Practical and Managerial Implications

For oil and gas project leaders, organizational decision-makers, and policymakers, the findings offer several concrete implications.

Prioritize sustainability practices as a foundational investment. Given that SPM practices exerted the strongest and most consistent effects across the model both directly on project success and indirectly through digital transformation organizations should treat sustainability integration not as a compliance overlay but as a core project management competency embedded in planning, stakeholder engagement, and resource management from project initiation onward.

Use sustainability practices as a springboard for digital investment. The strong SPM→DT path ($\beta = 0.482$) indicates that organizations seeking to accelerate digital transformation may achieve more traction by first strengthening sustainability-oriented management routines which create the data discipline, stakeholder coordination, and lifecycle thinking that digital tools require to function effectively rather than pursuing digitalization as a standalone technology initiative.

Strengthen risk management specifically to unlock the returns on sustainability practices. Because risk management significantly amplified the SPM success relationship, organizations with mature sustainability practices but underdeveloped risk management frameworks may be leaving substantial project success gains on the table. Investment in structured risk identification, assessment, and response planning should be viewed as a multiplier for existing sustainability initiatives rather than a separate, parallel workstream.

Do not assume digital and risk management investments must be bundled. The non-significant RM×DT interaction suggests that digital transformation initiatives can generate project success benefits somewhat independently of the surrounding risk management maturity, potentially because digital tools embed their own risk-sensing functionality. Organizations with resource constraints may therefore be able to sequence investments advancing digital transformation even where formal risk management processes are still maturing without proportionally sacrificing project success gains from digitalization.

Tailor practices across the multi-role project team. Because the sample spans project managers, engineers, HSE managers, procurement managers, and planning engineers, the findings imply that sustainability, digital, and risk management practices need coordinated ownership across functional roles rather than concentration within a single project management office, given that each role interacts with different facets of these practices during project execution.

6.5 Limitations of the Study

As with any single study, several limitations should be acknowledged. First, the cross-sectional design captures relationships at a single point in time and therefore cannot establish causality with the same rigor as a longitudinal or experimental design; the directional relationships proposed and tested should be interpreted as consistent with, rather than definitive proof of, causal ordering. Second, all constructs were measured via self-reported perceptual data from project professionals, which despite the collinearity-based reassurance reported in Section 5.3.2 cannot fully rule out common method variance. Third, the sample, while adequate for PLS-SEM estimation (n = 182), was drawn using non-probability purposive and snowball sampling rather than random sampling, which may limit the statistical generalizability of findings to the broader population of oil and gas project professionals across all regions and organizational types. Fourth, the study's demographic and organizational context (sector distribution, geography, project type/segment) was not fully detailed in the available results and should be transparently reported and discussed in the final manuscript, as sector-specific differences (e.g., upstream versus downstream, national oil company versus international operator) may condition the generalizability of the findings. Finally, the model, while explaining substantial variance in both digital transformation and project success, does not capture every plausible determinant of

project success in oil and gas projects (e.g., leadership style, organizational culture, macroeconomic volatility), leaving room for extension.

6.6 Recommendations for Future Research

Building on these limitations, several avenues for future research are recommended. Longitudinal or panel-based designs would allow researchers to test whether the strength of the SPM digital transformation project success pathway changes as digital maturity deepens over time, and whether the observed moderation asymmetry (significant for RM×SPMP, non-significant for RM×DT) persists or converges as risk management practices themselves become more digitally embedded. Future studies could also examine industry-specific boundary conditions in more depth for example, testing whether the moderating role of risk management differs across upstream, midstream, and downstream oil and gas segments, or between national oil companies and international operators, given their differing regulatory and risk exposure profiles. Additionally, researchers could extend the model by incorporating organizational culture, leadership style, or digital maturity stage (cf. Verhoef et al., 2021) as further moderators or mediators, to build a more complete picture of the mechanisms linking sustainability to project success. Finally, replicating this model in other high-risk, capital-intensive industries such as mining, nuclear energy, or large-scale infrastructure would help establish whether the asymmetric moderating role of risk management identified here is specific to oil and gas or reflects a broader pattern across similarly complex project environments.

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