Beyond net-zero carbon and the built environment for Agenda 2050 through environmental responsibility and strategic green decisions for sustainable cities

Smart and Sustainable Built Environment

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Abstract

Purpose – This study examines the impact of environmental knowledge and environmental values on sustainable project success (SPS), as well as the mediating role of green purchase intention (GPI) and the moderating effect of environmental responsibility in enhancing SPS.

Design/methodology/approach – We adopted a quantitative methodology to analyze a cross-sectional survey of 640 construction professionals using Partial Least Squares Structural Equation Modelling (PLS-SEM) to test the proposed model.

Findings – The findings demonstrate that environmental knowledge and environmental values significantly improve SPS, with $R^2 = 0.71$, which accounts for 71% of the variance of SPS and highlights the strength of these relationships. Further, GPI mediates these relationships, with indirect partial mediation effects for environmental knowledge (VAF = 51%) and environmental values (VAF = 53%) on SPS. Further, environmental responsibility moderates these relationships, with moderation effect sizes of $f^2 = 0.21$ for environmental knowledge and $f^2 = 0.25$ for environmental values, emphasizing the critical role of governance-driven environmental responsibility in strengthening behavioral translation mechanisms toward improved sustainability outcomes.

Originality/value – The originality of this study lies in contributing to the Theory of Planned Behavior (TPB) by empirically validating a contextually grounded moderated–mediation mechanism linking environmental knowledge and environmental values to SPS through GPI and environmental responsibility. Our study offers a theoretically refined and practically relevant sustainability framework by explicating behavioral and governance drivers within construction projects in a developing economy.

Keywords Environmental knowledge, Environmental values, Environmental responsibility, Green purchase intention, Sustainable project success, Pakistan

Paper type Research article

1. Introduction

Sustainability has become imperative for industry practitioners, public policymakers, and the general public, particularly propelling firms operating in the construction and built

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environment to embrace environmentally responsible behavior, mitigate environmental impacts, and enhance overall business performance (Lima *et al.*, 2021). According to the United Nations Environment Program (UNEP), the construction sector is a substantial contributor to global greenhouse gas (GHG) emissions, responsible for nearly 37% of total worldwide emissions (UNEP, 2025). The agency further stresses the need for fostering environmental sustainability initiatives and decarbonizing construction materials to achieve net-zero emissions from the built environment sector by 2050. At the same time, the construction sector consumes significant amounts of natural resources (Hasselsteen *et al.*, 2024) and contributes to environmental degradation, suggesting the urgent need for promoting sustainable construction practices to minimize the use of pristine natural resources and negative environmental impacts. Accordingly, construction companies are increasingly integrating environmental sustainability into business operations (Mellado and Lou, 2020) to minimize environmental footprints and address climate change (Willar *et al.*, 2021), which, in turn, enables companies to achieve sustainable project success (SPS). In the construction context, SPS refers to the incorporation of environmental sustainability criteria within construction projects, encompassing environmental impact mitigation, resource efficiency enhancement, reduction of waste generation, and the promotion of sustainable development (Nawaz *et al.*, 2025). Thus, in this study, we specifically focus on sustainable construction projects, assessing how environmental knowledge and values, and green purchase intention (GPI), influence SPS.

Environmental knowledge empowers construction teams to make environmentally friendly decisions, directly influencing SPS (Tavitiyaman *et al.*, 2024; Zameer and Yasmeen, 2022). Meanwhile, environmental values develop team cultures that focus on sustainability within direct project team members, promoting behaviors that support these objectives (Torkar and Bogner, 2019). GPI signifies a commitment to sustainable material selection and establishes practical connections between green knowledge and responsibility in the construction sector (Tao *et al.*, 2022). On the other hand, environmental responsibility encourages project stakeholders to implement sustainable practices that decrease their environmental impact for enhanced project sustainability (Góes *et al.*, 2023). Next, SPS is the desired outcome, assessing the effectiveness of these integrated environmental factors in delivering environmentally resilient and high-performance construction projects (Liaqat *et al.*, 2024; Murtagh *et al.*, 2020).

While several studies have investigated sustainability-related issues across various sectors, such as energy, finance, transport, and manufacturing, environmental sustainability issues in the construction sector need further scholarly attention (Góes *et al.*, 2023; Jaradat *et al.*, 2024). In particular, there is a paucity of research on how environmental knowledge and values, GPI, and the nuanced interactions among these variables affect SPS (Malik *et al.*, 2024). Further, there is a dearth of empirical research in a developing world context where the construction industry faces severe sustainability challenges, including inefficient resource use and a limited understanding of pro-environmental practices (Khan *et al.*, 2021; Shahid *et al.*, 2024).

Further, it is worthwhile to note that in developing countries such as Pakistan, workers often lack environmental knowledge, values, and GPI, which are crucial drivers of sustainable practices. This study highlights how environmental knowledge can motivate less-educated workers to adopt sustainable practices, and how GPI encourages the use of sustainable materials (Zameer and Yasmeen, 2022). In the absence of effective regulatory enforcement, environmental knowledge and GPI become even more crucial (Tavitiyaman *et al.*, 2024). They serve as catalysts for proactive sustainability actions, facilitating the adoption of sustainable practices even under weak regulatory enforcement (Purushothaman and Aguas, 2025). Environmental knowledge allows construction teams to make informed decisions that minimize environmental impacts, while GPI prioritizes sustainable materials and methods despite regulatory gaps (Shikur *et al.*, 2025; Vu *et al.*, 2022). This gap is particularly pronounced in developing countries such as Pakistan, where the construction industry suffers from poor resource management, limited technical sustainability-oriented competency, insufficient enforcement of sustainable environmental policies, and low levels of sustainability awareness (e.g. Iqbal *et al.*, 2021a; Iqbal *et al.*, 2021b; Khan *et al.*, 2021; Salimimoghadam *et al.*, 2025). Further, Ali and Mujahid (2024) highlighted that the construction industry is one of Pakistan's leading GHG emitters, accounting for approximately 30% of the country's total CO_2 emissions. Accordingly, this research seeks to bridge the gap in the literature by underscoring the need to investigate how environmental knowledge and values affect SPS, focusing on offering a more nuanced insight into GPI and environmental responsibility in Pakistan's construction industry.

To promote sustainability in smart and sustainable cities, solid waste reuse strategies are essential for reducing construction waste, conserving resources, and supporting the circular economy (Nawaz *et al.*, 2025). Within the construction sector, businesses and project teams can transform waste materials such as concrete, plastics, metals, and paper into valuable raw materials or secondary inputs, which can subsequently be utilized in other projects through industrial symbiosis (Tran *et al.*, 2025). This approach not only reduces the environmental burden but also minimizes project-level waste and conserves natural resources, directly supporting SPS. Furthermore, the classic typology of reverse logistics channels (reuse, recycling, and refurbishing) plays a significant role in the smart reuse of construction and municipal solid waste (Khan *et al.*, 2021). Reuse involves directly repurposing construction materials, recycling breaks down waste to create new building materials, and refurbishing restores products to their functional condition, all of which contribute to resource efficiency and sustainability in construction projects (Ma *et al.*, 2023). These practices are strongly influenced by environmental knowledge, which enables project teams to identify and implement reuse strategies, and environmental values, which shape the cultural mindset toward waste minimization. In addition, GPI drives the preference for recycled or refurbished materials in construction, while environmental responsibility reinforces stakeholders' commitment to adopting environmental practices (Akomea-Frimpong *et al.*, 2025). Collectively, these environmental factors promote efficient waste management, encourage the adoption of sustainable materials, reduce environmental impacts, and ultimately enhance SPS in urban environments (Li *et al.*, 2023).

The study's findings are expected to provide valuable insights into how sustainable practices might be effectively integrated into project management. Focuses on medium to large-scale construction projects across Pakistan, the study explores how environmental factors contribute to SPS despite unique challenges such as resource constraints and varying environmental regulations, while excluding smaller projects or other industries with different dynamics (Ali and Mujahid, 2024; Javed *et al.*, 2025; Vu *et al.*, 2022). This study contributes to the growing body of literature on sustainable construction practices by focusing on Pakistan, where the limited use of green resources and insufficient environmental knowledge pose significant challenges (Hasselsteen *et al.*, 2024; Iqbal *et al.*, 2021b). While there may be an inherent baseline level of sustainability culture, this research examines the specific influence of environmental knowledge and GPI on SPS. By exploring these factors, the study offers actionable insights to overcome the barriers that hinder the widespread adoption of sustainability practices in the construction sector.

Accordingly, this study addresses the primary research question: In what ways do environmental knowledge and environmental values affect SPS within Pakistan's construction sector, considering the mediating role of GPI and the moderating influence of environmental responsibility? To investigate these relationships, a survey-based research design was employed, targeting medium and large-scale construction projects. Surveys are ideal for identifying factors that influence environmental knowledge and values, and GPI, capturing diverse perspectives and experiences from a wide range of construction firms (Al-Swidi *et al.*, 2023). Moreover, this approach is suitable for gathering quantitative data, providing novel insights, and offering statistical analysis that can be generalized to a broader population of construction professionals (Briskorn and Dienstknecht, 2018).

Additionally, our study contributes to the existing literature on how environmental knowledge and values influence project outcomes in the construction sector, a perspective often overlooked in prior studies (Khan *et al*., 2021; Shahid *et al*., 2024). Further, we contribute to sustainability literature by exploring the collective influence of environmental knowledge, values, and behaviors on SPS in construction–an aspect frequently overlooked in prior studies (Amoako *et al*., 2020). Unlike previous studies that primarily examine general sustainability practices, this research focuses on understanding how specific environmental knowledge and values influence SPS and the mediating role of green purchasing intention and the moderating role of environmental responsibility, addressing a critical gap in the literature (Bresciani *et al*., 2023; Maqsoom *et al*., 2023). The findings provide theoretical insights into integrating sustainability within project management and practical guidance for project managers aiming to enhance competitive advantage through green practices, contributing to academic knowledge and sustainable construction practices (Malik *et al*., 2023; Martens and Carvalho, 2017).

The novelty of this study lies in contributing to the Theory of Planned Behavior (TPB) by advancing and empirically validating a contextually grounded moderated–mediation mechanism. Unlike previous studies that primarily focus on general environmental practices and broad sustainability outcomes (Li *et al*., 2019), this study introduces a nuanced theoretical mechanism that explains how environmental knowledge and environmental values are translated into measurable SPS through GPI and environmental responsibility within medium to large-scale construction projects in a developing economy such as Pakistan. Building on this theoretical extension, the study goes beyond examining these constructs in isolation and conceptualizes GPI as a behavioral translation mechanism through which cognitive (knowledge) and normative (values) drivers are operationalized into sustainability-oriented project outcomes (Bresciani *et al*., 2023; Tunji-Olayeni *et al*., 2023). This is a distinct shift from the typical focus on individual behavior in existing TPB-based research. At the same time, environmental responsibility is positioned as a critical boundary condition that strengthens this translation under weak regulatory and institutional environments (Xu and Liu, 2023). In the context of Pakistan's construction sector, which faces institutional constraints, limited enforcement of environmental regulations, resource inefficiencies, and sustainability capability gaps, environmental responsibility operates as an informal governance substitute and reinforces the translation of environmental knowledge, values, and green purchase-oriented decisions into measurable sustainable project outcomes. By integrating these relationships into a unified conditional process framework directly linked to SPS, this research goes beyond routine structural modeling applications and offers a theoretically grounded and context-specific contribution to sustainable construction and project management literature.

The remainder of the paper is organized as follows. The next section critically examines the literature review, with particular emphasis on environmental knowledge, environmental values, GPI, and SPS. Subsequently, the methodology section outlines the research design, sampling procedure, and analytical techniques employed. This is followed by the presentation and interpretation of the empirical results, along with a comprehensive discussion of the findings. The paper concludes with key implications and recommendations for future research directions.

2. Theoretical foundation and hypothesis development

2.1 Theoretical foundations

This study is grounded in the Theory of Planned Behavior (TPB) (Ajzen, 1991), which posits that behavior is determined by behavioral intention, shaped by attitudes, subjective norms, and perceived behavioral control. Within sustainability research, TPB has been widely applied to predict pro-environmental behaviors, green purchasing decisions, and environmentally responsible actions across individual and organizational contexts (Lau and Hashim, 2019). In construction projects, existing studies have primarily focused on explaining individuals' intentions to adopt green practices and sustainable technologies

(Hosseini *et al.*, 2026; Li *et al.*, 2019), rather than examining how such intentions translate into measurable project-level performance outcomes. Environmental knowledge and environmental values represent cognitive and normative antecedents within the TPB framework. Environmental knowledge enhances awareness of environmental consequences and strengthens perceived behavioral control (Tavitiyaman *et al.*, 2024), while environmental values reflect normative commitments that shape pro-environmental attitudes (Torkar and Bogner, 2019). While prior research acknowledges the importance of these aspects, the process through which these drivers translate into SPS remains theoretically underexplored, particularly in complex project-based environments (Malik *et al.*, 2023). This limitation becomes more pronounced in developing economies such as Pakistan, where environmental regulatory enforcement is relatively weak. Under such conditions, institutional gaps may hinder the conversion of pro-environmental intentions into actual performance outcomes (Javed *et al.*, 2025). Furthermore, internal governance mechanisms and responsibility norms may function as substitutes for formal regulatory enforcement (Vu *et al.*, 2022). Despite this contextual importance, prior TPB applications in sustainable construction have not explicitly modeled environmental responsibility as a boundary condition that strengthens behavioral translation under weak regulatory environments (Xu and Liu, 2023). Accordingly, this study extends TPB in three ways: first, it links environmental cognition and values to project-level sustainability performance rather than solely behavioral intention. Second, it conceptualizes GPI as a behavioral translation mechanism linking environmental knowledge and values to SPS. Third, it introduces environmental responsibility as a contextual boundary condition that strengthens the knowledge–intention–performance pathway. Through this extension, the study provides a context-sensitive enhancement of TPB within sustainable project management literature. By integrating cognitive drivers (knowledge), normative drivers (values), behavioral intention (GPI), and contextual responsibility mechanisms (environmental responsibility) within a unified framework, this research advances TPB from an individual behavioral model to a project-level sustainability performance model suited to institutionally constrained environments.

Despite the growing body of literature on sustainable project management and green procurement, important theoretical gaps remain (Malik *et al.*, 2023; Martens and Carvalho, 2017). In contrast to prior TPB-based sustainability studies (Shikur *et al.*, 2025), which predominantly focus on predicting individual pro-environmental intentions (i.e. consumer green purchasing or employee environmental behavior), this study shifts the analytical focus to project-level sustainability performance. Within the construction sector, existing green procurement studies largely examine determinants of GPI or supplier selection decisions at the firm or consumer level, without systematically linking these intentions to measurable SPS outcomes (Asaad and El-Sayegh, 2021). Similarly, sustainable project management frameworks often emphasize governance structures or sustainability capabilities (Fathalizadeh *et al.*, 2025), but do not explicitly model the behavioral translation mechanism connecting cognition, intention, and performance under weak regulatory conditions (Magano *et al.*, 2025). Moreover, prior research rarely models environmental responsibility as a boundary condition that materially alters this behavioral translation pathway. Consequently, limited attention has been given to how cognitive drivers (environmental knowledge), normative drivers (environmental values), and governance-based responsibility structures interact within a unified behavioral model to influence SPS. By integrating these elements within a moderated mediation TPB framework, this study addresses this unresolved gap and offers a theoretically differentiated approach tailored to sustainable construction project environments in developing economies, such as Pakistan.

2.2 Hypotheses development

2.2.1 Environmental knowledge and SPS. Environmental knowledge has consistently been recognized as a critical driver of pro-environmental behavior and sustainability-oriented decision-making (Bresciani *et al.*, 2023). Within the construction industry, green knowledge enhances awareness of environmental impacts, enabling project teams to adopt resource-efficient and environmentally responsible practices and improve sustainability outcomes (Amoako *et al.*, 2020). Drawing on the TPB, environmental knowledge strengthens perceived behavioral control and shapes informed attitudes toward sustainable practices, thereby influencing environmentally responsible actions (Al-Swidi *et al.*, 2023; Islam and Mehdi, 2024). Empirical studies in construction contexts have shown that environmentally informed teams are more likely to implement waste reduction, energy-efficient technologies, and sustainable material selection practices (Wang *et al.*, 2022). Similarly, environmental values reflect individuals' normative commitments and moral beliefs towards environmental protection and shape pro-environmental attitudes within project teams (Torkar and Bogner, 2019). Within the TPB framework, such values shape favorable attitudes toward sustainable behavior and influence sustainability-oriented decision-making (Ajzen, 1991; Maqsoom *et al.*, 2023). Within the construction context, project teams that endorse strong environmental values are more inclined to prioritize waste minimization, responsible resource allocation, and sustainable technologies (Tran *et al.*, 2025). While the importance of environmental knowledge and values in promoting pro-environmental behavior and sustainability adoption is widely acknowledged, existing studies have primarily focused on behavioral intention or general organizational practices rather than project-level performance outcomes. As a result, the direct linkage between cognitive and normative environmental drivers and measurable SPS remains theoretically underdeveloped, particularly within developing-country construction contexts (Mensah *et al.*, 2020; van der Poll, 2022). To address this gap, we explicitly examine the direct effects of environmental knowledge and environmental values on SPS within medium to large-scale construction projects in the developing-country construction context of Pakistan, where sustainability implementation is influenced by institutional constraints, resource limitations, and evolving regulatory frameworks. By linking cognitive and normative drivers to measurable project-level outcomes, this research extends beyond intention-based models and contributes to clarifying how sustainability-oriented mindsets influence actual project performance in developing-economy construction contexts. Accordingly, the following hypotheses are proposed:

H1. Environmental knowledge is positively associated with SPS.

H2. Environmental values are positively associated with SPS.

2.2.2 The mediating role of GPI between environmental knowledge and SPS. GPI has been extensively examined within the TPB framework as a predictor of pro-environmental purchasing behavior (Tao *et al.*, 2022). However, existing studies have primarily investigated GPI in consumer behavior and firm-level contexts, focusing on how environmental knowledge, environmental values, or environmental concern influence individuals' or organizations' intentions to purchase green products (Santos -Corrada *et al.*, 2024). This gap is particularly important in construction projects, where procurement decisions directly influence material selection, supplier choice, lifecycle costs, and environmental performance. Environmental knowledge enhances awareness of environmental impacts and strengthens perceived behavioral control over sustainable decisions (Al-Swidi *et al.*, 2023), while environmental values shape normative commitments toward environmentally responsible actions (Haws *et al.*, 2014; Torkar and Bogner, 2019). These cognitive and normative drivers are expected to influence GPI, which in turn shapes procurement-related actions that directly affect sustainable project performance (Zameer and Yasmeen, 2022). Moreover, although TPB-based research frequently identifies environmental knowledge and environmental values as important predictors of pro-environmental intention, limited attention has been given to understanding how intention functions as a behavioral translation mechanism within complex project-based environments. In sustainable project management research, green procurement is typically conceptualized as an operational strategy or governance mechanism (Song *et al.*, 2017); however, it is rarely examined as a behavioral mediating pathway that translates environmental cognition and normative values into measurable sustainable project performance outcomes. As a result, the process through which environmental knowledge and values are operationalized into concrete procurement-related actions that improve project-level sustainability performance remains theoretically underdeveloped within project-based environments (Tong *et al.*, 2023). This limitation is particularly relevant in construction sectors operating within developing economies, where institutional constraints and weak regulatory enforcement may hinder the direct translation of pro-environmental attitudes into project outcomes. In such contexts, procurement decisions represent a critical operational channel through which environmental knowledge and values can be enacted in practice (Song *et al.*, 2017; Wong *et al.*, 2016). Conceptualizing GPI as a mediator, therefore, provides a theoretically grounded explanation of how cognitive and normative drivers are translated into measurable SPS through procurement-oriented behaviors. Accordingly, this study empirically tests a mediated pathway in which GPI transmits the effects of environmental knowledge and environmental values onto SPS within medium to large-scale construction projects in the developing-country context of Pakistan. This approach advances prior TPB-focused sustainability research by explicitly linking cognition, intention, and measurable performance outcomes within project management environments. Accordingly, the following hypotheses are proposed:

H3. GPI mediates the relationship between environmental knowledge and SPS.

H4. GPI mediates the relationship between environmental values and SPS.

2.2.3 Environmental responsibility moderates the relationship between environmental knowledge and SPS. Environmental responsibility has been widely examined within sustainability research as a direct predictor of pro-environmental behavior and as an organizational value influencing sustainability performance (Guan *et al.*, 2023). Within the construction and project management literature, environmental responsibility is often conceptualized as part of governance structures, leadership commitment, or corporate social responsibility-related initiatives (Powell *et al.*, 2011). However, existing studies have predominantly treated environmental responsibility as an independent antecedent of sustainability outcomes rather than as a boundary condition that alters the strength of behavioral translation pathways (Vu *et al.*, 2022). Furthermore, Amjad *et al.* (2025) demonstrate that green human resource management enhances sustainability outcomes via employee engagement, underscoring the role of organizational mechanisms in behavioral translation. While Li *et al.* (2025) acknowledge that responsibility norms may strengthen the implementation of sustainable practices, there is limited empirical evidence for whether environmental responsibility moderates the relationship between environmental knowledge, pro-environmental intention, and measurable project-level sustainability performance. In particular, prior studies that employed TPB in the construction and project management context rarely investigate environmental responsibility as a moderator that conditions the strength of the knowledge–intention–performance pathway. This limitation becomes especially relevant in construction sectors operating in developing economies such as Pakistan, where environmental regulatory enforcement may be inconsistent or weak (Ali and Mujahid, 2024; Javed *et al.*, 2025). Under such institutional conditions, the translation of environmental knowledge and values into procurement decisions and project performance is more likely to depend on internal responsibility norms and governance mechanisms (Niesten and Jolink, 2020). In the absence of strong external enforcement, environmental responsibility may function as an informal governance substitute that strengthens the conversion of pro-environmental cognition and intention into concrete project-level outcomes (Xu and Liu, 2023). Accordingly, this study conceptualizes environmental responsibility not merely as a direct predictor, but as a contextual boundary condition that moderates the knowledge–intention–performance pathway within construction project environments. Specifically, when environmental responsibility is high, project teams are more likely to operationalize environmental knowledge and values into procurement-related behaviors that enhance SPS. By modeling this moderation effect, the study extends prior TPB-based sustainability research by demonstrating that behavioral translation is contingent upon governance-driven environmental responsibility structures and by incorporating institutional context into the behavioral model. In doing so, it offers a refined explanation of how sustainability performance emerges in weak-regulation construction environments within developing economies such as Pakistan. Through this argument, the following hypotheses are proposed.

H5. Environmental responsibility moderates the relationship between environmental knowledge and GPI such that the relationship is strengthened when environmental responsibility is high.

H6. Environmental responsibility moderates the relationship between environmental values and GPI such that the relationship is strengthened when environmental responsibility is high.

The theoretical framework is shown in Figure 1.

3. Research methodology

This study utilizes a quantitative research design (Karupiah, 2022) to investigate how sustainable practices influence SPS in the construction sector, considering the mediating role of GPI and the moderating effect of environmental responsibility. Participants were recruited from project-based roles, specifically project directors, project managers, and sustainability officers involved in construction projects. The study population comprised construction practitioners actively engaged in sustainability-related projects across major cities in Pakistan. The country was selected as the study context due to its rapidly developing economy, accelerating urbanization, and growing institutional emphasis on environmentally responsible construction practices. Focusing on professionals operating in metropolitan areas captures the construction sector's response to green initiatives amid urban expansion and increasing environmental challenges. A hybrid sampling strategy, combining random and convenience sampling techniques, was employed for participant recruitment. To clarify, convenience

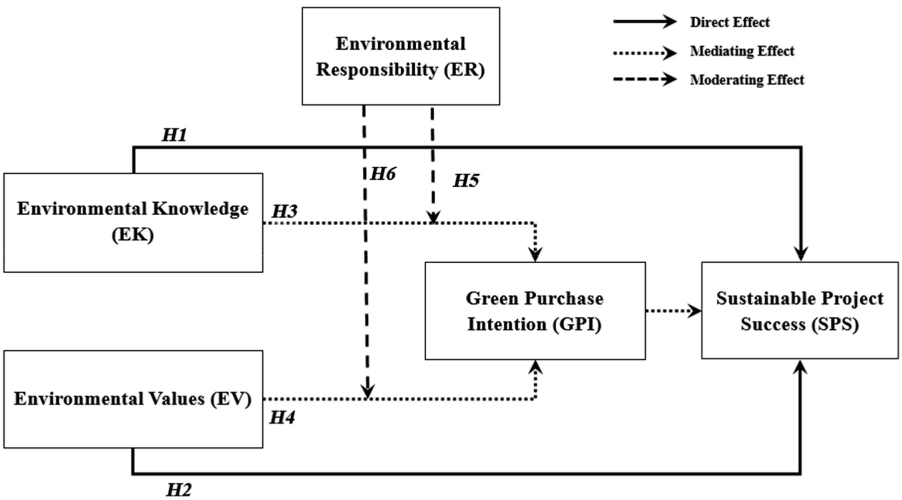

Figure 1. Theoretical framework

sampling was used to select readily accessible participants, such as project directors, project managers, and sustainability officers in key construction firms, while random sampling was applied within this group to enhance the generalizability of the results (Winton and Sabol, 2022). Survey data were obtained from construction professionals associated with various construction projects. For some projects, multiple informants were surveyed, including project directors, project managers, and sustainability officers, to capture perspectives aligned with their different roles. When we analyzed project responses from multiple respondents, we applied a systematic approach designed to ensure data integrity, incorporating the following: we conducted consistency checks, organized follow-up interviews, and performed inter-rater agreement tests, with the purpose of verifying that any observed discrepancies could be attributed exclusively to individual perspectives rather than misinterpretation of the data (Belur *et al.*, 2018; Hulland *et al.*, 2018).

3.1 Measurement instruments and data collection procedures

The survey instrument utilized a five-point Likert scale, comprising the responses "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." Environmental knowledge was measured using a four-item scale adapted from (Leonidou and Skarmeas, 2017). Environmental values were measured through a five-item scale adapted from (Haws *et al.*, 2014). Environmental responsibility was measured through a six-item scale adapted from (Powell *et al.*, 2011). For GPI, a three-item scale was adapted from (Chan and Lau, 2000). Regarding SPS, a fifteen-item scale was adapted from (Liaqat *et al.*, 2024). Further, as the total population is unknown, the sample-to-item ratio method was applied, as suggested by Lakens (2022). There were 33 questions in our study. Out of 1089 survey invitations sent to relevant staff working on 529 construction projects, 706 responses were received from those involved in 343 construction projects, and 640 valid and relevant responses from 320 construction projects were selected, as recommended by Watanabe *et al.* (2024). In cases where more than one respondent rated the same project, the responses were compared and examined for internal consistency, and then aggregated by calculating the mean score for each item. These averaged scores were used to represent one project-level response in order to ensure that each project was treated as one unit of analysis and the non-independence of observations was avoided (Fink, 2010). Participants were briefed about the study's aims, procedures, and responsibilities, and their rights prior to participation. Accordingly, informed and voluntary consent was obtained from each respondent. Furthermore, data collection was conducted only after securing authorization from their immediate reporting authorities. Although self-reported data may introduce social desirability bias, we minimized this risk by ensuring anonymity, confidentiality, and voluntary participation (Sutrop and Lõuk, 2020). A structured paper-based survey was employed to collect data from construction industry practitioners within key metropolitan areas of Pakistan. The entire data collection procedure was conducted through physical distribution and collecting completed questionnaires from the participants as suggested by Ward *et al.* (2012). The data were collected over a nine-week timeframe. To enhance participation and improve response rates, bi-weekly reminders were sent to the construction professionals involved in the study. Additional interviews were held during this time to obtain some clarifying qualitative data, especially to clarify discrepancies within the data and to validate the responses. After discrepancies were observed, 21 follow-up interviews were conducted with project-level informants for clarification purposes, rather than for modifying survey responses. These interviews were used solely to understand the contextual factors behind divergent perceptions, ensuring that differences were due to real perceptual differences rather than misinterpretation of the survey items. The original survey data were neither modified nor re-coded based on interview insights, and no qualitative data were incorporated into the statistical analysis. Thus, the study maintains a robust cross-sectional quantitative approach, minimizing methodological bias. This procedure is consistent with methodological recommendations for validating survey-based findings in complex project environments (Conrad and Schober, 2021; Scott *et al.*, 2021) and is supported by existing research, where follow-up interviews were conducted solely for clarification purposes (Nawaz *et al.*, 2025).

3.2 Common method bias

Common method bias (CMB) was addressed through a combination of procedural and statistical remedies. Procedurally, the study ensured that all questionnaire items were brief and clear to reduce ambiguity. In addition, data were collected in three intervals using a three-wave time-lag approach, following Srivastava *et al.* (2025), to minimize the risk of CMB. Furthermore, reverse-coded items were employed and distributed throughout the questionnaire to reduce response bias. These items were carefully re-coded prior to analysis to ensure consistency. To further mitigate potential bias, the Variance Inflation Factor (VIF) was applied to assess multicollinearity. According to (Kock, 2015), VIF values above 3.3 indicate potential multicollinearity and CMB concerns. However, the highest VIF value recorded in this study was 2.38, which falls within the acceptable range, confirming that multicollinearity and CMB were not problematic. Additionally, Harman's single-factor test was conducted to further examine the presence of common method bias. The results indicated that the cumulative variance extracted by a single factor was 39.761%. Since this value is below the recommended threshold of 50% (Zhang *et al.*, 2022), the findings suggest that common method bias does not pose a significant concern in this study.

3.3 Data analysis technique

Data analysis was conducted using IBM SPSS and SmartPLS 4 to examine the proposed relationships. SPSS was used in assessing the variances, while PLS-SEM was used for path analysis (Sarstedt and Mooi, 2019). Structural equation modeling can be conducted using two primary approaches: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). These techniques are complementary and not competitive (Leguina, 2015; Sarstedt *et al.*, 2022). This study deployed a partial least square structural equation model (PLS-SEM), a robust statistical approach well-suited for analyzing complex interdependencies among variables and testing theoretical models with multiple constructs (Hair *et al.*, 2019). PLS-SEM was selected over CB-SEM for hypothesis testing because it is better suited to the characteristics of the collected data, particularly its non-normal distribution. PLS-SEM does not require data to have a normal distribution (Dash and Paul, 2021; Hair *et al.*, 2017). Moreover, CB-SEM is primarily used in confirming already established theories, while PLS-SEM is much preferred for exploratory studies (Henseler and Schuberth, 2025; F. Hair Jr *et al.*, 2014). As the examination of sustainable practices influencing SPS through mediating and moderating mechanisms represents an emerging area within construction research, PLS-SEM was deemed suitable due to its flexibility in handling complex and exploratory models. PLS-SEM is preferred in examining (predicting) constructs and relationships in complex structural models (relationships, directions, and strength) (Hair *et al.*, 2017; Sarstedt *et al.*, 2022). Overall, PLS-SEM remains preferred over the covariance-based option for its simplicity, precision, and agility (Dash and Paul, 2021; Henseler and Schuberth, 2025).

4. Analysis and results

This study adopts a rigorous quantitative approach to analyze the relationships between environmental knowledge, environmental values, environmental responsibility, GPI, and SPS using rigorous statistical techniques to ensure data-driven analysis.

4.1 Descriptive statistics

The respondents' demographic information is detailed in Table 1. The survey targeted construction professionals across Pakistan, including both male and female participants, with

Table 1. Characteristics of respondents

Category	Options	Frequency	Percentage (%)
Gender	Male	286	89.4
	Female	34	10.6
Age (Years)	18–23	51	15.9
	24–32	187	58.4
	33–42	68	21.3
	Above 42	14	4.4
Educational level	Bachelor's	176	55.0
	Master's	42	13.2
	MS/MPhil	91	28.4
	PhD	11	3.4
Work experience (Years)	Below 7	37	11.6
	7–14	189	59.1
	15–20	66	20.6
	21–26	17	5.3
	Above 26	11	3.4
Project duration (Months)	18–24	32	10.0
	25–36	56	17.4
	37–60	125	39.1
	61–78	87	27.2
	Above 78	20	6.3
Project team size (Employees)	21–60	45	14.1
	61–120	176	55.0
	121–180	58	18.1
	181–240	25	7.8
	241–300	16	5.0

males comprising 89.4% of the sample. A majority of respondents were between 24 and 32 years old (58.4%) and held a bachelor's degree (55%). Most participants reported seven to fourteen years of work experience (59.1%). Concerning project attributes, the highest response rate was associated with projects of 41–60 months' duration (39.1%), while projects with team sizes of 61–120 employees represented 55% of the sample. The findings indicate that the respondent profile was predominantly composed of male construction professionals aged between 24 and 32 years. Most participants held bachelor's degrees and possessed considerable industry experience, reflecting a relatively young and professionally competent sample within the construction sector. The rest of the details can be seen in Table 1. In Table 2, the values of kurtosis (−7 to +7) and skewness (−2 to +2) of all variables are within acceptable ranges as suggested by Sarstedt and Mooi (2019).

4.2 Measurement model

The measurement model was assessed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to evaluate the reliability and validity of the constructs. These key measures were factor loadings, Cronbach's alpha, composite reliability, convergent validity, and discriminant validity, as suggested by existing literature (Bonett and Wright, 2015). The assessment of the measurement model was conducted prior to hypothesis testing to ensure reliability and validity criteria. As shown in Table 3, all constructs met the recommended benchmarks (Sarstedt *et al*., 2019), with average variance extracted (AVE) values above 0.50 and internal consistency indices exceeding 0.70. The observed Cronbach's alpha values ranged from 0.799 to 0.891, rho-A from 0.812 to 0.897, and rho-C from 0.881 to 0.925. These constructs captured the variance of their respective items as the AVE values were between 0.570 and 0.761, which exceeds the threshold of 0.5. In addition, all items' factor loadings surpassed the threshold of 0.7, as suggested by F. Hair Jr *et al*. (2014), demonstrating

Table 2. Descriptive statistics and correlations for the variables

	Mean	SD	Kurtosis (−7 to +7)	Skewness (−2 to +2)	Correlations 1	2	3	4	5	6	7	8	9	10	11
1. Gender	1.106	0.309	0.095	2.568	1.000										
2. Age group	2.141	0.727	0.529	0.467	0.072	1.000									
3. Education	1.803	0.967	0.936	0.633	0.007	0.257	1.000								
4. Work experience	2.300	0.870	0.756	1.134	0.047	0.482	0.288	1.000							
5. Project duration	3.022	1.049	1.100	−0.241	0.133	0.037	0.135	0.144	1.000						
6. Project team size	2.347	0.983	0.967	1.030	0.002	0.040	0.092	0.063	0.020	1.000					
7. Environmental knowledge	3.165	3.250	−1.401	−0.014	0.033	0.088	0.053	0.016	0.006	0.102	1.000				
8. Environmental values	2.986	3.000	−0.888	0.124	0.045	0.095	0.003	0.091	0.073	0.057	0.421	1.000			
9. Green purchase intention	3.360	3.667	−0.956	−0.496	0.006	0.120	0.056	0.057	0.020	0.045	0.850	0.358	1.000		
10. Environmental responsibility	2.937	2.667	−1.058	0.519	0.038	0.094	0.047	0.062	0.011	0.073	0.881	0.520	0.834	1.000	
11. Sustainable project success	2.931	2.857	−1.247	0.167	0.088	0.043	0.050	0.099	0.058	0.066	0.697	0.259	0.691	0.660	1.000

Note(s): Sample size (n) = 320; SD: Standard deviation; Kurtosis should be between "−7 to +7", Skewness should be between "−2 to +2", **Correlation is significant at the 0.01 level (2-tailed)

Table 3. Construct robustness of measurement model

Constructs	Items	Factor loadings	VIF	Cronbach alpha (α)	CR (rho-A)	CR (rho-c)	AVE
Environmental knowledge	EK1- I know how construction activities contribute to environmental degradation	0.816	1.46	0.891	0.892	0.925	0.761
	EK2- I know environmental standards and certifications in construction projects	0.88	1.59				
	EK3- I am knowledgeable about sustainable practices reducing waste and emissions	0.902	1.81				
	EK4- I am confident in identifying environmentally friendly materials and technologies for construction projects	0.877	1.56				
Environmental values	EV1- I consider environmental impacts when making work-related decisions	0.771	1.55	0.887	0.897	0.922	0.753
	EV2- I care about avoiding waste of natural resources	0.905	1.73				
	EV3- I see myself as environmentally responsible in my work	0.899	1.57				
	E4- I am willing to accept inconvenience for environmentally friendly practices	0.880	1.45				
Environmental responsibility	ER1- I take actions to reduce environmental impacts	0.882	1.82	0.871	0.879	0.909	0.720
	ER2- I take accountability for adopting sustainable practices in my work	0.784	1.73				
	ER3- I ensure construction activities align with environmental protection standards	0.866	1.62				
	ER4- I actively support using eco-friendly materials and green technologies	0.844	1.57				
	ER5- I encourage my team to prioritize environmental responsibility	0.913	1.72				
	ER6- I am committed to improving sustainability outcomes	0.794	1.25				
Green purchase intention	GPI1- I consider using eco-friendly materials in my work	0.897	1.69	0.799	0.812	0.881	0.718
	GPI2- I intend to adopt sustainable materials and technologies	0.807	1.74				
	GPI3- I intend to prioritize suppliers offering sustainable solutions	0.827	1.30				
Sustainable project success	SPS1- "Was the project completed on budget with minimal environmental impact?	0.777	2.38	0.841	0.852	0.898	0.570
	SPS2- Was the project completed on time while focusing on resource efficiency?	0.758	1.62				
	SPS3- Was the project completed as planned, meeting environmental goals?	0.782	1.74				
	SPS4- Did the product meet eco-friendly specifications and performance standards?	0.792	1.85				
	SPS5- Did the project address customer needs and environmental concerns?	0.791	1.71				
	SPS6- Did the project boost profitability with eco-conscious methods?	0.774	1.80				
	SPS7- Did the project enhance ROI through green initiatives?	0.763	1.90				
	SPS8- Did the project generate lasting social benefits through responsible practices?	0.727	2.17				
	SPS9- Did the project foster the development of green innovations?	0.781	2.17				
	SPS10- Did the project introduce innovative, sustainable technologies?"	0.765	2.24				
	SPS11- Were economic benefits sustained with minimal environmental impact?	0.723	1.89				
	SPS12- Were the project's environmental benefits long-lasting?	0.766	1.63				
	SPS13- Did the project create new opportunities for sustainable growth?	0.743	2.24				
	SPS14- Did the project manage risks while ensuring sustainability goals?	0.705	2.17				

Note(s): α represents Cronbach's alpha, CR denotes Composite Reliability, AVE indicates Average Variance Extracted, and the sample size was $N = 320$

each item's strong relationship with its respective construct. All variables' VIF values were lower than the accepted threshold of 3.3, thereby confirming the absence of multicollinearity, which verifies the measurement model's stability and reliability (Fornell and Bookstein, 1982). The findings confirm the adequacy of the theoretical framework and provide a robust foundation for conducting the subsequent structural model evaluation.

4.3 Discriminant validity

Following the recommendations of Henseler *et al*. (2015), we calculated the Heterotrait-Monotrait (HTMT) ratio to assess the discriminant validity. As presented in Table 4, all the HTMT ratios were below the recommended value of 0.85, indicating clear evidence of discriminant validity established between the constructs. Furthermore, the Fornell-Larcker criterion was satisfied, as the square root of the AVE of each construct was higher than its correlations with other constructs, which is an indication of satisfactory construct distinctiveness. This analysis was performed to assess the threshold criteria for evaluating the discriminant validity. The results show that all constructs meet the required standards to show a distinct and robust measurement model.

4.4 Model fitness

The model's goodness of fit was evaluated in SmartPLS 4 using multiple fit indices, including SRMR, d_ULS, d_G, χ^2/df, and NFI as shown in Table 5. The SRMR value of 0.07 falls below the recommended threshold of 0.08, indicating an excellent model fit. The discrepancy measures (d_ULS = 2.710; d_*G* = 2.110) were lower than those of the saturated model and below the bootstrapped HI95% values, thus remaining consistent with acceptable model fit criteria as recommended by Henseler *et al*. (2016). The estimated model's chi-square value ($\chi^2 = 1681.85$, df = 517, $p < 0.001$) was only slightly lower than that of the saturated model ($\chi^2 = 1701.34$, df = 517, $p < 0.001$), suggesting a good fit. The χ^2/df value of 3.25 falls within the acceptable threshold of less than 5, indicating good model fit. Additionally, the NFI value of 0.92 exceeds the recommended threshold of 0.90, indicating an excellent fit. Collectively,

Table 4. Discriminant validity

Variables	Environmental knowledge	Environmental responsibility	Environmental values	Green purchase intention	Sustainable project success
Discriminant validity (HTMT)					
Environmental knowledge					
Environmental responsibility	0.838				
Environmental values	0.518	0.785			
Green purchase intention	0.701	0.609	0.710		
Sustainable project success	0.755	0.706	0.582	0.698	–
Fornell-Larcker criteria					
Environmental knowledge	0.820				
Environmental responsibility	0.816	0.831			
Environmental values	0.660	0.548	0.806		
Green purchase intention	0.766	0.753	0.593	0.714	
Sustainable project success	0.695	0.660	0.716	0.669	0.661

Table 5. Model fitness

Abbreviation		Result	Fitness
SRMR	Standardized Root Mean Squared Residual	0.07	Excellent
d_ULS	Unweighted Least Squares Distance	2.710	Excellent
d_G	Geodesic Distance	2.110	Excellent
χ^2	Chi-square	1681.85	Good
df	Degrees of freedom	517	Good
(χ^2/df)	Chi-square/Degrees of freedom	3.25	Good
NFI	Normed Fit Index	0.92	Excellent

these indices demonstrate the adequacy, stability, and robustness of the proposed structural model, following the guidelines suggested by (Goretzko *et al.*, 2024).

4.5 Structural model

The structural model was assessed using Structural Equation Modeling (SEM) criteria, including the coefficient of determination (R^2) and predictive relevance (Q^2), as reported in Table 6. According to guidelines (Hair *et al.*, 2019), $R^2 \geq 0.26$ represents substantial, $R^2 \geq 0.13$ moderate, and $R^2 \geq 0.02$ weak explanatory power, and $Q^2 > 35$ represents strong predictive relevance. The results show that both endogenous constructs exhibit substantial explanatory power. GPI recording 63.3% R^2 and SPS at 71.1% illustrate a strong and good relationship, respectively. These findings suggest that the model has strong explanatory capability, particularly for SPS. Predictive relevance was examined using the Q^2 statistic obtained through the blindfolding procedure. A Q^2 value greater than 0.35 reflects strong predictive relevance. The Q^2 values for GPI (0.41) and SPS (0.49) exceed this benchmark, confirming the model's strong predictive accuracy. Additionally, blindfolding results provide SSO (Sum of Squares Observations) and SSE (Sum of Squares Errors) values. For GPI, these are 1753.00 SSO and 1034.27 SSE, whereas for SPS, these are 5171.00 SSO and 2637.21 SSE. Overall, these indicators confirm that the model demonstrates robust explanatory power and meaningful predictive relevance, particularly for SPS.

4.6 Hypotheses testing

4.6.1 Direct and moderating effects. We examine the relationships of the structural model with regard to each particular construct using PLS-SEM (Kock, 2016). The detailed assessment of the proposed model as analyzed within each construct is presented in Table 7 and Figure 2, where each hypothesis is considered statistically significant based on path coefficient (β), standard deviation (SD), t-value, *p*-value, CI, and lower and upper limits, with the CI set to 95% for understanding the results. Table 7 illustrates the results, suggesting that environmental knowledge (H1) and environmental values (H2) have notable influences on SPS. Specifically,

Table 6. Coefficient of determination and predictive relevance metrics

Variables	R-Square	Benchmark value	R-Square adjusted	SSO	SSE	Q^2 (=1-SSE/SSO)	Benchmark value
Green Purchase Intention	0.63	>0.26	0.61	1753.00	1034.27	0.41	>0.35
Sustainable Project Success	0.71	>0.26	0.68	5171.00	2637.21	0.49	>0.35

Table 7. Direct and moderation effects

Hypothesis	Relationship	β	SD	t	p	Effect size (f^2)	Confidence interval 2.50%	97.50%	Status
Direct effect									
H1	EK→SPS	0.414	0.053	7.811	0.000***	0.42	0.310	0.518	Accepted
H2	EV→SPS	0.305	0.027	11.29	0.000***	0.39	0.252	0.158	Accepted
	EK→GPI	0.590	0.067	8.806	0.000		0.459	0.721	
	EV→GPI	0.349	0.038	9.184	0.000		0.275	0.223	
	GPI→SPS	0.602	0.047	12.80	0.000		0.510	0.751	
Moderation effect									
H5	ER* EK →GPI	0.236	0.047	5.021	0.007**	0.21	0.144	0.328	Accepted
H6	ER* EV →GPI	0.199	0.038	5.237	0.009**	0.25	0.125	0.273	Accepted

Note(s): Significant at: *$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$
EK = Environmental Knowledge, EV = Environmental Values, EK = Environmental Responsibility, GPI = Green Purchase Intention, SPS=Sustainable Project Success

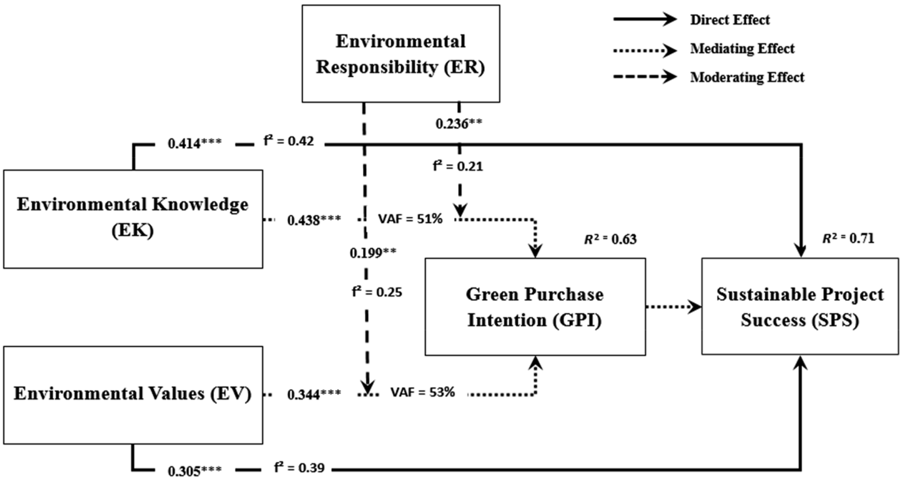

Figure 2. Hypotheses testing

environmental knowledge showed a significant effect (β = 0.414, t = 7.811, $p < 0.000$ and CI limits = 0.310, 0.518), as did environmental values (β = 0.305, t = 11.29, $p < 0.000$ and CI limits = 0.252, 0.158), confirming H1 and H2 hypotheses. Furthermore, environmental responsibility was examined as a moderating variable for the relationships of environmental knowledge and GPI (H5) and environmental values and GPI (H6). The results confirmed significant moderation as shown in Table 7, with ER strengthening the environmental knowledge-GPI relationship (β = 0.236, t = 5.021, p = 0.007 and CI limits = 0.144, 0.328) and the EV-GPI relationship (β = 0.199, t = 5.237, p = 0.009 and CI limits = 0.125, 0.273), thus supporting H5 and H6. Furthermore, (Ledermann *et al.*, 2025) state that an f^2 value of 0.35 represents a large effect, 0.15 represents a medium effect, and 0.02 represents a small effect. Table 7 demonstrates the following EK → SPS (0.42) and EV → SPS (0.39), which represent large effect sizes. Additionally, ER x EK → GPI (0.21) and ER x EV → GPI (0.25), representing medium effect sizes. Thus, all the hypotheses are accepted, and the results validate the proposed model, demonstrating the critical role of environmental knowledge, environmental values, and environmental responsibility in enhancing GPI and ultimately driving SPS in construction projects.

4.6.2 Mediation effect. The study assessed the indirect role of GPI as a mediator between environmental knowledge, environmental values, and SPS, and the results are presented in Table 8 and Figure 2. The results validate that GPI was partially mediating each of the relationships, according to the VAF threshold presented by (Ledermann *et al.*, 2025), which suggests that a VAF <20% shows no mediation, 20–80% partial mediation, and >80% full mediation. Specifically, H3 investigates the mediating effect of GPI in the relationship between environmental knowledge and SPS. The results show a positive and significant mediating effect ($\beta = 0.438$, $t = 8.588$, $p < 0.001$), with confidence intervals between 0.338 and 0.538, demonstrating the robustness of the mediating effect. Similarly, H4 tests the mediating impact of GPI on the relationship between environmental values and SPS. The results show a significant positive mediation effect ($\beta = 0.344$, $t = 11.090$, $p < 0.001$) with confidence intervals between 0.283 and 0.405. Collectively, the results provide substantial empirical evidence that GPI is a significant partial mediator that explains the translation from environmental knowledge and values to sustainable project outcomes.

5. Discussion

This study addresses a critical gap in existing literature by integrating GPI and environmental knowledge, values, and responsibility into one unified framework. Previous studies have focused on these constructs in a fragmented manner, and limited attention has been given to their combined influence towards achieving SPS, particularly in the context of Pakistan's construction sector (Negash Yeneneh and Hassan Abdiqani, 2020). The primary aim of this research was to elucidate the influences of environmental knowledge and values on SPS with the mediating effect of GPI and the moderating effect of environmental responsibility, based on a survey of 640 construction professional respondents working in medium to large-scale construction projects in Pakistan. The findings indicated that environmental knowledge and values enhance the outcomes of sustainable construction projects, while green purchasing intention and environmental responsibility act as mediators and moderators that propel outcomes on sustainable construction. The study also aims to provide helpful knowledge to reinforce environmentally responsible decisions during the construction processes.

The findings demonstrated that environmental knowledge significantly affects SPS ($\beta = 0.414$, $p < 0.001$). Effective project management derives from environmental knowledge,

Table 8. Mediation effects

Hypothesis	Path	β	SD	*t*- value	*p*-value	Confidence interval 2.50%	97.50%	Total effects	VAF	Decision
Mediation effect										
H3	EK→GPI→SPS	0.438	0.051	8.588	0.000***	0.338	0.538	0.852	51%	Partial Mediation
H4	EV→GPI→SPS	0.344	0.031	11.09	0.000***	0.283	0.405	0.649	53%	Partial Mediation

Note(s): Significant at: *$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$
EK = Environmental Knowledge, EV = Environmental Values, EK = Environmental Responsibility, GPI = Green Purchase Intention, SPS=Sustainable Project Success

which encompasses the employment of green materials, energy-efficient equipment, and advanced waste management techniques. These practices, as noted by Khan *et al*. (2021), enhanced project team compliance, which improved successful project completion. Similarly, Jaradat *et al*. (2024) claim that environmentally conscious proactive action enhances results, thereby having a positive impact on overall environmental performance while satisfying stakeholders' expectations that resource allocation is optimized in a construction project. In addition, Huang and Shih (2009) and Malik *et al*. (2024) advocate including environmental factors (environmental knowledge and environmental values) in the planning stages of a project for the reduction of materials waste and the environmental footprint of construction activities. These observations are especially applicable in Pakistan, where the implementation of sustainable approaches is still developing. According to Hasselsteen *et al*. (2024), the absence of environmental awareness among construction workers leads to less optimal outcomes. Enhanced targeted training activities increase environmental literacy, thus enabling sustainability integration and global project performance improvement. Building on the TPB, knowledge is considered a crucial organizational resource for competitive advantage (Amoako *et al*., 2020).

Similarly, environmental values were identified as having a positive impact on the success of a project ($\beta = 0.305$, $p < 0.00$). These values shape organizational priorities that guide construction professionals toward promoting sustainability in construction practices (Loosemore and Alkilani, 2026). According to Haws *et al*. (2014), this fosters green values in organizations for environmental conservation and ensures projects meet global objectives. Such alignment is essential in Pakistan, where environmental consciousness is slowly emerging. Integrating environmental values fosters the adoption of practices such as using fewer natural resources, low carbon emissions, and environmentally certified materials. In the context of project management, Reed *et al*. (2014) argued these approaches could simultaneously decrease the environmental footprint and enhance stakeholder satisfaction, resulting in more favorable outcomes for projects. Chen *et al*. (2020) argued that incorporating the environmental dimension into a project's organizational culture nurtures innovation towards achieving its sustainability objectives. Empirical evidence also supports the influence of environmental values on decision-making processes. Furthermore, Purushothaman and Aguas (2025) and Willar *et al*. (2021) found green issues motivate firms to spend money on training employees and acquiring advanced sustainable practices and technologies, thereby reinforcing the firm's competitiveness.

As mediated by GPI, there is a relationship between environmental knowledge and SPS ($\beta = 0.438$, $p < 0.001$). Tavitiyaman *et al*. (2024) commented that environmental knowledge is insufficient to foster sustainability in construction projects without a strong GPI. The intention to buy green materials and technologies enhances sustainable practices and project results (Zameer and Yasmeen, 2022). Research indicates that environmental awareness plays a crucial role in the decision-making process concerning green procurement. During the procurement stage, project teams utilize environmental awareness to integrate greener materials and technologies into construction projects as outlined by Zhang *et al*. (2024). Equally, Wong *et al*. (2016) further assert that the adoption of green procurement policies is essential for reducing waste and enhancing resource efficiency, which, in turn, enables the achievement of sustainability outcomes. Moreover, Tan and Goh (2018) reveal that the intention to purchase green products assists in the mitigation of environmental compliance and project schedule risks, thereby facilitating smoother execution. Song *et al*. (2017) propose that construction firms committed to green purchasing and green procurement policies not only align with sustainability metrics, but also enhance stakeholder value and the reputation of the organization. Despite these ramifications, however, (Wong *et al*., 2016) noted some constraining factors, such as insufficient green procurement resources and a lack of training, which restrict the adoption of green purchasing. The construction sector, in overcoming these challenges, would utilize environmental knowledge to improve project results.

According to the data, GPI significantly mediates the effects of environmental values on the success of sustainable projects ($\beta = 0.344$, $p < 0.001$). This indicates that environmental values within the construction industry are critically oriented towards enhancing sustainability choices. The integration of environmental values within the operations and processes of the construction industry helps to achieve SPS. Green procurement policies in construction industries advance sustainable procurement practices, as Agbesi *et al*. (2018) state, so these findings support the results of this study. In addition, Maqbool *et al*. (2022) and Jaradat *et al*. (2024) assert that projects with a sustainable focus and profound environmental concern tend to incorporate more renewable resources and mitigate eco-destructive activities, hence reinforcing sustainability. Similarly, Maqsoom *et al*. (2023) argue that a construction industry that embraces green values has better compliance with environmental regulations and overall improved project performance. Taking these steps toward green purchasing, such products transform the intention behind the "green" label into tangible action. Moreover, Agbesi *et al*. (2018) and Wong *et al*. (2016) found that projects in the construction sector which actively pursue green procurement tend to improve innovation and productivity. Xia *et al*. (2019) also claim that the lack of green organizational values in construction projects is due to challenges such as reluctance to change and insufficient training. These barriers need to be addressed if companies are to incorporate eco-friendly values into the procurement decision process and enhance project results.

The moderation effect was supported by the findings, indicating environmental responsibility as a moderating factor between the environmental knowledge and GPI relationship ($\beta = 0.236$, $p = 0.007$). This suggests that businesses in the construction sector who have a high sense of responsibility towards the natural environment are more likely to use their environmental knowledge in actionable ways toward green purchasing decisions, which aids in achieving SPS. Regarding the construction sector, environmental responsibility determines how practitioners use their expertise to utilize sustainable approaches. Vu *et al*. (2022) highlight how such responsibility drives construction firms to embrace sustainability in their operations proactively, which translates to GPI. Srivastava *et al*. (2025) emphasize that firms with high levels of environmental responsibility strategically and operationally integrate sustainability as a business imperative with a focus on long-term relationships, enhancing project outcomes. Responsible companies, as noted by Huang and Shih (2009), create systems to manage the processes whereby environmental knowledge is used and incorporated into daily practices and decision-making.

Environmental responsibility moderates the relationship between environmental values and GPI, having a positive impact ($\beta = 0.199$, $p = 0.009$). This implies that those construction firms that are willing to bear environmental responsibility frequently adopt green values during the procurement process, which in turn aids in aligning construction projects with sustainability (Powell *et al*., 2011; Vu *et al*., 2022; Xu and Liu, 2023). According to Ferri and Pedrini (2018), firms that embrace environmental responsibility ensure that such perspectives are practically integrated into all processes, including purchasing, rather that remaining as merely conceptual notions. Furthermore, Haws *et al*. (2014) highlight that companies that hold environmental values as a priority tend to incorporate the use of sustainable, more environmentally friendly materials and technologies to enhance project sustainability.

The current study explores the role of environmental responsibility as a moderator and GPI as a mediator in promoting sustainability within the construction sector. Unlike previous research that analyzed these factors independently, this study integrates environmental factors and GPI into a unified framework to examine their combined effect on SPS. The findings suggest that promoting environmental responsibility and encouraging eco-conscious decision-making can drive long-term sustainability in the construction sector in Pakistan. GPI plays a key role in enhancing project success and is further supported by environmental responsibility, which fosters the adoption of environmental factors, driving overall sustainability in construction projects.

6. Conclusion, implications, and future research directions

6.1 Conclusion

This study advances understanding of how environmental knowledge and environmental values can be systematically embedded within construction practices to enhance SPS. Beyond confirming their direct and indirect effects through GPI and environmental responsibility, the findings highlight that sustainability performance is not merely a technical issue but also a behavioral and governance-driven process. Integrating environmental knowledge into structured training systems, procurement decision frameworks, and project evaluation mechanisms can institutionalize sustainability across project lifecycles. Similarly, reinforcing environmental values through organizational culture, leadership commitment, and accountability systems can ensure that sustainability principles are operationalized rather than remaining aspirational. GPI serves as a critical operational channel linking environmental awareness to measurable project-level sustainability performance, while environmental responsibility strengthens this translation, particularly in contexts characterized by weak regulatory enforcement. From a broader perspective, these findings suggest that sustainable construction requires alignment between cognitive drivers (knowledge), normative commitments (values), procurement mechanisms, and governance responsibility structures within project management systems. For developing countries facing regulatory gaps and resource constraints, public policymakers can strengthen green public procurement regulations, introduce mandatory environmental certification standards for construction materials, provide fiscal incentives for sustainable procurement, and require project-level sustainability reporting to accelerate sector-wide sustainability transitions. By demonstrating how behavioral and governance mechanisms interact to influence measurable project outcomes, this study offers both a theoretically refined model and a practical roadmap for advancing sustainable construction performance in contexts facing similar institutional sustainability challenges worldwide.

6.2 Implications

6.2.1 Theoretical implications. This study advances the literature by introducing a context-specific boundary condition and clarifying the behavioral translation mechanism within weak-regulation environments. While prior studies that employed the TPB perspective mostly examine individual pro-environmental behavior, this research extends the TPB to the project level by empirically demonstrating how cognitive (environmental knowledge) and normative (environmental values) aspects translate into SPS through GPI. This study also provides empirical evidence that GPI functions as a behavioral translation mechanism through which environmental cognition and values are translated into procurement-related actions that directly influence project-level sustainability outcomes. This reframes the TPB within project sustainability literature by emphasizing procurement decision pathways as the mechanism through which behavioral intentions materialize into measurable performance results. In the context of Pakistan’s construction sector, where regulatory enforcement is relatively weak, environmental responsibility operates as a critical boundary condition and informal governance substitute that compensates for limited institutional enforcement. The findings demonstrate that moderation materially alters the strength of the knowledge–intention–performance pathway, indicating that behavioral intentions alone are insufficient unless reinforced by responsibility-driven governance mechanisms. This provides fresh theoretical insight by demonstrating that TPB mechanisms function differently in institutional environments characterized by regulatory gaps. By empirically validating this moderated mediation structure at the project level, the study contributes a refined TPB framework that integrates cognitive and normative drivers, behavioral intention, and contextual responsibility mechanisms into a unified sustainability-performance model. Thus, the findings suggest that TPB-informed sustainability models in project environments should explicitly account for institutional context and governance strength when predicting sustainable performance outcomes. Accordingly, this study extends the TPB beyond individual behavior models and offers a theoretically grounded explanation of how sustainability behaviors are operationalized in construction project contexts within developing economies.

6.2.2 Practical implications. The findings provide actionable guidance for construction practitioners, project teams, and policymakers in developing economies, such as Pakistan. First, given the significant role of environmental knowledge, construction firms should institutionalize structured environmental training programs for project directors, managers, sustainability officers, and procurement teams. This may include mandatory sustainability workshops, on-site environmental briefings, lifecycle assessment training, and regular updates on green building standards. Embedding sustainability modules into professional development programs can enhance informed decision-making at the project level. Second, since GPI mediates the relationship between environmental knowledge and environmental values on SPS, procurement systems should be redesigned to prioritize certified green materials and environmentally responsible suppliers. Firms can introduce supplier evaluation criteria based on environmental certifications, carbon footprint disclosures, and other relevant environmental standards. Procurement policies should also incorporate green budgeting allocations and lifecycle cost analysis to encourage long-term sustainability rather than short-term cost minimization. Third, the moderating role of environmental responsibility suggests that sustainability must be operationalized through governance mechanisms. Firms should formalize environmental responsibility through sustainability KPIs, accountability frameworks, internal audits, and sustainability-linked performance incentives. Appointing sustainability officers at the project level and integrating environmental targets into performance appraisals can strengthen responsibility-driven behavior. At the policy level, regulators in Pakistan should align procurement standards with environmental certification requirements, introduce tax incentives for green materials, and strengthen enforcement of sustainability reporting requirements. These measures will reinforce environmental responsibility and amplify the effectiveness of knowledge- and value-driven sustainability initiatives. Collectively, these targeted interventions translate the study's empirical findings into concrete managerial and policy actions, enhancing SPS in developing-country construction contexts.

6.2.3 Policy and societal implications. The findings of this study provide policy-relevant insights for advancing sustainable construction practices within developing-country contexts such as Pakistan. Rather than directly claiming emission reductions, the study identifies behavioral and governance mechanisms that can contribute to measurable environmental improvements in construction projects. First, the mediating role of GPI indicates that procurement reform is a critical leverage point for policy intervention. Public procurement authorities may strengthen environmental certification requirements, lifecycle-based evaluation criteria, and supplier disclosure standards to encourage the adoption of low-carbon materials, recycled inputs, and resource-efficient construction methods. Such procurement alignment can contribute to reductions in embodied carbon, material waste, and energy intensity. Second, the moderating role of environmental responsibility indicates that governance reinforcement is essential in institutional environments characterized by limited regulatory enforcement. Policymakers can support this through strengthened sustainability reporting frameworks, environmental compliance audits, and the integration of environmental performance benchmarks within national construction standards which may enhance accountability and reduce the gap between policy and practice. Third, enhancing environmental knowledge through technical training programs, certification schemes, and knowledge-sharing platforms can improve environmental literacy among professionals. Improved knowledge diffusion can indirectly contribute to better waste management practices, support circular economy practices (e.g. reuse and recycling of construction materials), and strengthen sustainability-oriented project outcomes. Collectively, procurement reform, governance accountability, environmental responsibility, and knowledge development represent actionable pathways through which sustainability-oriented behaviors translate into measurable societal impact. Although this study does not directly quantify emissions or waste reduction, it empirically identifies the behavioral and governance conditions that increase the likelihood of measurable environmental and compliance improvements within developing-economy construction sectors.

6.3 Limitations and future research directions

This study has several limitations that should be acknowledged. First, the cross-sectional research design limits the ability to establish causal relationships among environmental knowledge, environmental values, environmental responsibility, and SPS. Although the sample included 640 construction professionals representing 320 projects, the focus on a single national context may limit the generalizability of the findings to other regions and industry settings, thereby constraining external validity. Additionally, the reliance on self-reported survey data introduces the possibility of response bias, as participants may overestimate their engagement in sustainability-related practices, potentially affecting the accuracy of the results. Future research should consider adopting longitudinal designs to better capture causal dynamics and temporal variations in sustainability-related behaviors and outcomes. Expanding the sampling frame to include professionals from diverse industries and geographical contexts would further enhance generalizability. Moreover, integrating mixed-method approaches that triangulate quantitative and qualitative data sources could help mitigate self-report bias and provide richer contextual insights. Finally, future studies should examine sustainable practices and Industry 5.0 initiatives for SPS through intrinsic drivers such as sustainable leadership innovation capability, and sustainable project culture, alongside extrinsic factors including stakeholder collaboration and government support.

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