Green Intellectual Capital, Sustainability Control Systems, and Environmental Performance: Bridging Natural Resource Orchestration and Levers of Control Perspectives

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Abstract

Understanding how organizations translate sustainability-oriented intangible assets into tangible environmental outcomes remains an important challenge in sustainability accounting and management control research. Drawing on the natural resource orchestration perspective, this study examines how sustainability control systems, grounded in Simons' levers of control framework, help translate green intellectual capital (GIC) components into improved environmental performance. Using survey data from 175 listed Indian firms and applying partial least squares structural equation modelling (PLS-SEM), the results show that GIC is positively associated with environmental performance, and the sustainability control systems variable mediates this relationship. The study contributes to the sustainability management control literature by integrating natural resource orchestration theory with the levers of control framework. The findings offer firm-level implications by showing that merely possessing green knowledge assets does not necessarily lead to improved environmental performance. Instead, firms need to orchestrate these assets through sustainability control systems by effectively structuring, bundling, and leveraging them to translate GIC into stronger environmental outcomes. The findings also provide practical insights for managers and regulators seeking to strengthen environmental performance through the strategic integration of GIC and sustainability control systems.

Keywords: Sustainability control systems; Simons' levers of control; Green intellectual capital; Environmental performance; Management control systems; Natural resource orchestration

Paper type: Research paper

1. Introduction

In recent years, growing environmental challenges, intensified regulatory pressures, and rising stakeholder expectations have compelled firms to rethink how they deal with sustainability-related issues. Organizations are increasingly expected not only to comply with environmental regulations but also to proactively integrate sustainability into their strategies and operations (Beusch et al., 2022). In response, firms have begun to develop environmentally oriented capabilities, including eco-innovation, green knowledge, and sustainability-oriented managerial control systems, to support environmentally responsible business activities. Among these capabilities, green intellectual capital (GIC), which encompasses green human capital, green structural capital, and green relational capital, has emerged as an important source of environmental value creation (Chen, 2008; Chang and Chen, 2012).

Although prior research has documented the role of GIC in enhancing environmental performance (Wats et al., 2025), an important question remains regarding how firms convert green knowledge resources into tangible environmental outcomes. This issue is particularly important because firms may invest in green human expertise, sustainability-related organizational routines, and environmentally oriented stakeholder relationships without necessarily achieving improved environmental performance (Asiaei et al., 2026). When these resources are not effectively coordinated through appropriate organizational mechanisms, they may remain fragmented, underutilized, or disconnected from strategic and operational decision-making. Therefore, understanding the mechanism through which GIC is translated into environmental performance is vital for firms seeking to ensure that investments in green knowledge assets generate measurable environmental benefits. In this regard, the extant literature shows that management control systems can play a critical role in translating strategic sustainability intentions into operational practices and measurable outcomes (Fagerlin et al., 2026; Edirisinghe et al., 2025; Hasu et al., 2025).

Prior studies have begun to examine this issue by focusing on specific mechanisms such as environmental management accounting and environmental performance measurement systems (Asiaei et al., 2022a; Asiaei et al., 2022c; Barani et al., 2025). However, these studies primarily emphasize environmental information, measurement, and reporting mechanisms. Less is known about how broader sustainability control systems help firms mobilize, coordinate, and strategically deploy GIC to achieve environmental performance. This distinction is important because sustainability control systems do not merely measure environmental outcomes; rather, they embed sustainability objectives into managerial control processes, strategic dialogue, organizational learning, and decision-making. Accordingly, this study examines sustainability control systems as a key mechanism through which firms orchestrate GIC and translate green knowledge assets into improved environmental performance.

To address this gap, this study draws on the notion of natural resource orchestration, which emphasizes the role of managerial actions in structuring, bundling, and leveraging environmental resources to achieve strategic objectives (Asiaei et al., 2022a). This perspective is rooted in resource orchestration theory, which argues that firms must not only possess valuable resources but also effectively orchestrate them to gain a competitive advantage

(Sirmon et al., 2011). In the context of this study, sustainability control systems provide an organizational mechanism through which firms can mobilize, coordinate, and deploy GIC toward environmental objectives. This framing allows us to examine not only whether GIC contributes to environmental performance, but also how green knowledge resources are structured, bundled, and leveraged through sustainability control systems to generate environmental outcomes.

Building on this perspective, the present study proposes that sustainability control systems act as a key mediating mechanism linking GIC to environmental performance. Prior studies have examined how environmental management accounting and environmental performance measurement systems support the relationship between GIC and environmental performance (Asiaei et al., 2022a; Asiaei et al., 2022c; Barani et al., 2025). However, environmental performance measurement systems are primarily concerned with identifying, measuring, monitoring, and reporting environmental performance indicators. Although such systems are important for tracking environmental outcomes, they provide a narrower view of how firms translate green knowledge resources into strategic and operational action. In contrast, sustainability control systems, grounded in Simons' levers of control framework, represent a broader strategic management control mechanism (Wijethilake, 2017). They not only monitor sustainability-related targets through diagnostic controls but also stimulate managerial dialogue, learning, adaptation, and strategic attention through interactive controls. This distinction is important because the effective use of GIC requires more than environmental measurement; it requires control processes that enable firms to coordinate green human capital, green structural capital, and green relational capital toward environmental objectives. Therefore, unlike prior studies that focus primarily on environmental measurement mechanisms, this study demonstrates how sustainability control systems function as a strategic control mechanism through which firms orchestrate GIC to enhance environmental performance.

This study empirically examines these relationships in the context of India, an emerging economy where corporate environmental accountability has increasingly shifted from voluntary sustainability narratives toward more structured and mandatory sustainability disclosure. In particular, the Securities and Exchange Board of India introduced the Business Responsibility and Sustainability Reporting framework, which requires large listed firms to provide detailed disclosures on environmental, social, and governance issues (SEBI, 2021).

This framework is directly relevant to the present study because its environmental principle requires firms to disclose information on energy consumption, water use, air emissions, greenhouse gas emissions, waste management, and environmental compliance (SEBI, 2021). These requirements create increasing pressure on firms not only to report environmental outcomes but also to develop internal knowledge resources, reporting routines, and control processes that support reliable sustainability-related information and decision-making. Accordingly, India provides a particularly relevant context for examining how firms mobilize GIC and sustainability control systems to enhance environmental performance.

Using survey data from senior managers of firms listed in the NSE 500 index, this study investigates how GIC influences environmental performance and examines the mediating role of sustainability control systems in translating GIC elements into environmental outcomes. The NSE 500 provides an appropriate sampling frame because it represents a broad cross-section of India's listed corporate sector, covering large, mid, and small-cap firms across multiple industries, while also capturing a substantial proportion of the free-float market capitalisation and trading activity of stocks listed on the National Stock Exchange (NSE Indices Limited, 2026). This makes it a suitable setting for examining firms that are economically significant and exposed to increasing sustainability reporting and environmental accountability expectations.

This study offers three contributions. First, it extends the literature on GIC by shifting attention from the mere possession of green knowledge resources to the managerial orchestration of these resources through sustainability control systems. Second, it contributes to the sustainability management control literature by demonstrating the mediating role of sustainability control systems in translating environmental resources into environmental performance. Third, by examining these relationships in the context of India's evolving sustainability governance framework, the study provides new insights into how firms in emerging economies align internal capabilities with environmental objectives. While this study focuses on GIC and its impact on sustainability control systems and environmental performance within a developing country, it extends the natural resource orchestration perspective (Asiaei et al., 2022a) by presenting a novel model. This model facilitates an understanding of how GIC and sustainability control systems (based on Simons' levers of control view) create a synergy to contribute to environmental performance, an area that remains underexplored.

The rest of the paper is structured as follows. Section 2 presents the literature review, along with developing the hypothesis, followed by the description of the research methodology in Section 3. Section 4 deals with data analysis and reports. Section 5 concludes with key findings, implications, limitations, and future research directions.

2. Literature review and hypothesis

2.1 Theoretical foundations and positioning

Research on GIC draws on multiple theoretical perspectives to explain how environmentally oriented knowledge resources contribute to organizational outcomes. Prior studies have frequently grounded GIC in the resource-based view (RBV) and the knowledge-based view, which emphasize the strategic value of intangible knowledge assets in generating competitive advantage. Building on these perspectives, the intellectual capital-based view highlights how human, structural, and relational knowledge resources collectively shape firm performance (Reed et al., 2006). Other studies adopt the triple bottom line perspective and green intellectual capital-based view (Rehman et al., 2025, 2026), which emphasizes the simultaneous pursuit of economic, environmental, and social objectives. Another related stream of sustainability and intellectual capital research has further drawn on resource orchestration theory to explain how managerial actions structure, bundle, and leverage resources to achieve strategic outcomes (Asiaei et al., 2022a, 2023a, 2026; Andersén, 2023).

Against this background, the present study adopts the natural resource orchestration perspective because it directly aligns with the central objective of this study: to explain how firms translate GIC into environmental performance through sustainability control systems. This perspective extends resource orchestration logic (Sirmon et al., 2011) to the environmental domain by emphasizing how managers structure, bundle, and leverage green resources to address sustainability-related challenges (Asiaei et al., 2022a). It is therefore particularly suitable for the present study because the research problem is not simply whether firms possess green knowledge assets, but how these assets are mobilized and converted into environmental outcomes. In this study, GIC represents the firm's green knowledge resource base, sustainability control systems represent the organizational mechanism through which these resources are coordinated and deployed, and environmental performance represents the outcome of this orchestration process. Accordingly, the natural resource orchestration

perspective provides a coherent theoretical lens for examining the mediating role of sustainability control systems in the relationship between GIC and environmental performance.

Resource orchestration involves three interrelated managerial processes: structuring, bundling, and leveraging (Sirmon et al., 2011). In the context of this study, structuring refers to developing and organizing green knowledge resources within the firm, including employees' environmental expertise, sustainability-oriented routines and systems, and relationships with environmentally oriented stakeholders. These resources correspond to the three components of GIC: green human capital, green structural capital, and green relational capital (Chen, 2008; Chang and Chen, 2012). Bundling refers to integrating these resources into organizational capabilities that support sustainability-related action, while leveraging refers to deploying these capabilities through appropriate organizational mechanisms to achieve environmental objectives. Sustainability control systems are therefore central to this process because they provide the control mechanisms through which firms coordinate green knowledge resources, monitor environmental priorities, stimulate managerial dialogue, and translate sustainability-related capabilities into measurable environmental performance.

Prior studies have examined different mechanisms through which firms translate green knowledge resources into environmental outcomes. For example, environmental management accounting and environmental performance measurement systems have been shown to translate the effect of GIC into environmental performance by improving environmental information, measurement, and reporting processes (Asiaei et al., 2022a, 2022c). However, less attention has been paid to sustainability control systems as broader strategic management control mechanisms that go beyond measurement by guiding managerial decision-making, strategic alignment, organizational learning, and the deployment of sustainability-related resources. This distinction is important for the present study because our objective is not only to examine whether GIC improves environmental performance, but also to explain how sustainability control systems enable firms to orchestrate green knowledge resources toward environmental objectives.

Building on this theoretical logic, we argue that sustainability control systems represent a key mechanism through which organizations orchestrate green intellectual resources. Drawing on Simons' (1995) levers of control framework, these systems enable firms to use

diagnostic controls to monitor environmental objectives and interactive controls to support dialogue, learning, and strategic adaptation around sustainability challenges (Wijethilake, 2017). Through these mechanisms, sustainability control systems help firms structure, bundle, and leverage GIC to enhance environmental performance. Accordingly, as illustrated in Figure 1, this study proposes that sustainability control systems mediate the relationship between GIC and environmental performance by enabling the effective orchestration of green intellectual resources.

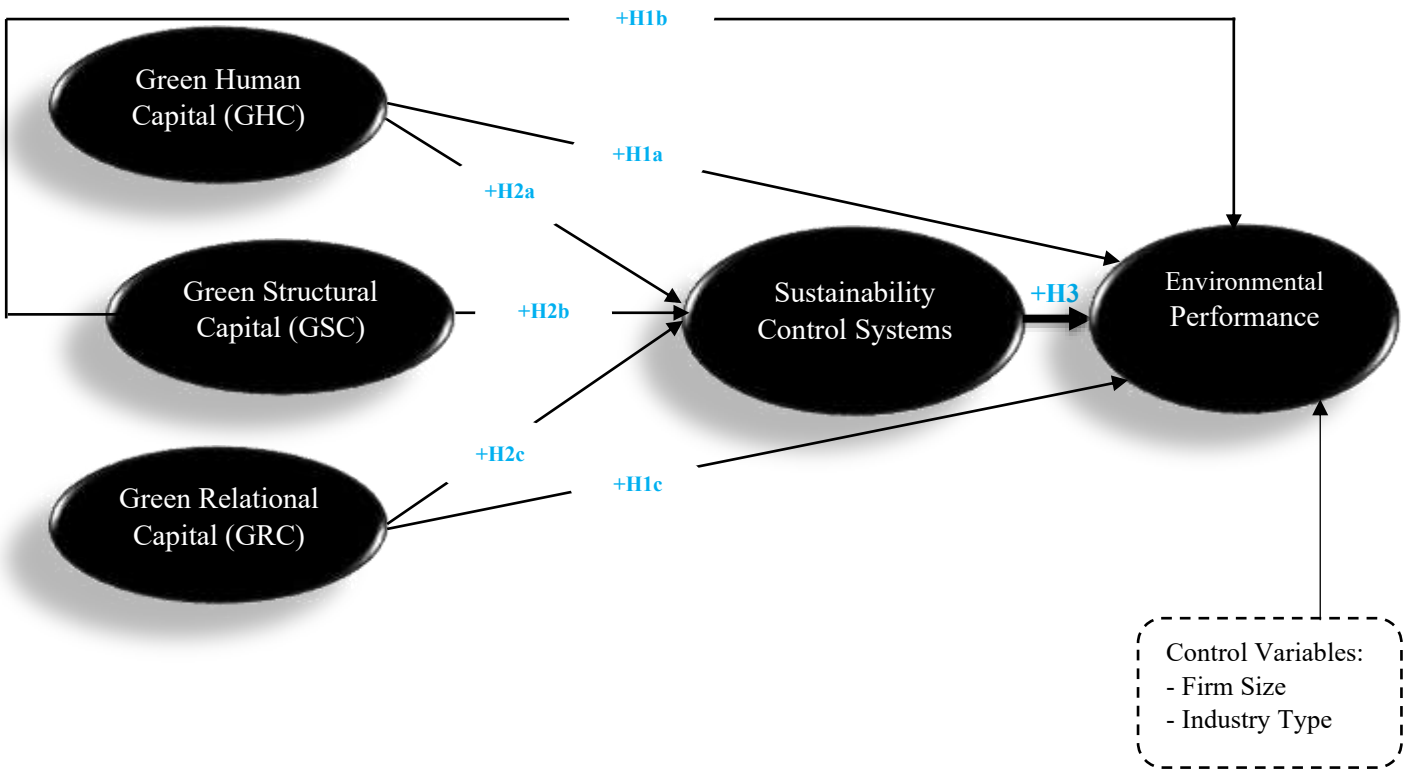

Figure 1: Theoretical Model

Based on this theoretical foundation, the following sections develop hypotheses linking the components of GIC, sustainability control systems, and environmental performance.

2.2 GIC and environmental performance

Environmental awareness has become a critical concern, yet there is no consensus on the precise definition or scope of environmental performance. While some define it through measurable aspects like emissions and waste disposal (Mungai et al., 2020), others consider broader metrics, such as environmental rankings or external assessments (Lisi, 2015; Henri &

Journeault, 2010). This study adopts Judge and Douglas's (1998) definition, framing environmental performance as a firm's ability to meet and exceed societal expectations regarding environmental stewardship. This conceptualization emphasizes both environmental impacts and the collaborative alignment with green-focused stakeholders (Lisi, 2015).

GIC refers to the stock of intangible assets, knowledge capabilities, and relationships that support environmental protection and green innovation at both individual and organizational levels (Chang & Chen, 2012, p. 77). It comprises three key components: green human capital, green structural capital, and green relational capital. The positive association between GIC and environmental performance can be explained through the resource-based view, the intellectual capital-based view, and the natural resource orchestration perspective. From a resource-based and intellectual capital-based view, GIC represents a valuable and difficult-to-imitate knowledge resource that enables firms to develop environmental capabilities and respond more effectively to ecological pressures. From a natural resource orchestration perspective, these resources contribute to environmental performance when firms structure, bundle, and leverage them toward environmental objectives.

Green human capital refers to employees' knowledge, skills, experience, and commitment to environmental protection and innovation (Chen, 2008). Employees with stronger environmental expertise are better able to identify environmental risks, recognize inefficiencies in resource use, support pollution prevention practices, and contribute to green innovation. Such knowledge and skills help firms translate environmental awareness into operational improvements, including waste reduction, cleaner production, and more effective compliance with environmental standards (Huang & Kung, 2011; Song et al., 2021). Prior empirical evidence also suggests that green human capital supports green learning and innovation, which in turn contribute to improved environmental performance (Asiaei et al., 2022a).

Green structural capital refers to the organizational systems, routines, databases, policies, technologies, and processes that support environmental management (Chen, 2008). Unlike individual knowledge, green structural capital embeds environmental knowledge into organizational practices, making sustainability-related capabilities more systematic and less dependent on particular employees. Through environmental policies, knowledge management systems, green technologies, and operational routines, firms can institutionalize environmental

practices and improve their ability to monitor, manage, and reduce environmental impacts. Empirical studies show that green structural capital supports environmental strategies, green technological advancement, and organizational responsiveness to environmental challenges (Amores-Salvadó et al., 2021; Widener, 2006; Jardon & Dasilva, 2017).

Green relational capital refers to a firm's relationships with external stakeholders, including customers, suppliers, regulators, business partners, and community groups, that support environmental collaboration and innovation (Chen, 2008). These relationships can improve environmental performance by giving firms access to external environmental knowledge, collaborative problem-solving opportunities, supplier engagement, and stakeholder feedback. Strong green relational capital also helps firms respond to institutional pressures and align their environmental strategies with external expectations, thereby strengthening both environmental legitimacy and environmental outcomes (Chuang & Huang, 2018; Dickel et al., 2018; Wang et al., 2021).

Taken together, these arguments suggest that GIC enhances environmental performance by providing the knowledge, organizational infrastructure, and stakeholder relationships needed to identify environmental problems, implement environmental practices, and sustain green innovation. Empirical studies further support this reasoning by showing that GIC is associated with green absorptive capacity, green business strategies, green creativity, and environmental performance (Begum et al., 2023; Forenten et al., 2026). Based on this discussion, we hypothesize:

Hypothesis 1: There is a positive association between GIC elements (green human capital, green structural capital, and green relational capital) and environmental performance.

2.3 GIC and sustainability control systems

Management control systems refer to the formal and informal routines and procedures managers use to maintain or alter patterns in organizational activities (Simons, 1995). Sustainability control systems represent a sustainability-oriented form of management control that helps firms align sustainability strategies with operational practices and environmental objectives (Wijethilake & Upadhaya, 2020; Ruiz-Blanco et al., 2026). In the management control literature, sustainability control systems have been discussed through different

frameworks, including Malmi and Brown's (2008) control package, the sustainable balanced scorecard (Schaltegger, 2011), eco-controls (Henri & Journeault, 2021), and the levers of control perspective. These frameworks collectively show that sustainability control systems are not limited to measuring environmental outcomes; rather, they support the integration of sustainability into planning, monitoring, learning, decision-making, and organizational culture (Jollands et al., 2015).

By bridging strategy and operations, sustainability control systems can reduce uncertainty, support accountability, and help firms translate sustainability objectives into operational routines and measurable outcomes (Ittner & Larcker, 1997; Heggen & Sridharan, 2021). In response to escalating regulatory pressures and environmental awareness, firms are increasingly incorporating sustainability challenges into core strategies rather than treating them merely as compliance issues (Corsi & Arru, 2021). Prior research also shows that the effective application of sustainability control systems can foster environmental innovation and corporate performance. For instance, Journeault (2016) demonstrates that eco-controls advance environmental competencies such as eco-learning, innovation, and stakeholder integration. Similarly, Wijethilake et al. (2018) show that the use of control systems can shape the relationship between environmental innovation strategies and performance outcomes. These insights suggest that sustainability control systems provide an important organizational mechanism through which firms can coordinate sustainability-related resources and actions.

The design and implementation of sustainability control systems are influenced by the type and extent of knowledge-based resources within an organization (Asiaei et al., 2023). Organizations with well-developed GIC, comprising green human capital, green structural capital, and green relational capital, are more likely to adopt sustainability control systems due to the intrinsic alignment between these resources and the strategic requirements for sustainability. For instance, employees with strong environmental expertise and dedication, representing green human capital, can foster an organizational culture that emphasizes accountability and proactive environmental stewardship (Ahakwa & Tackie, 2024). This culture creates a natural demand for sustainability control systems to systematically monitor, measure, and manage environmental impacts. In this context, management control systems in general and sustainability control systems in particular serve as the operational backbone, aligning employee efforts with strategic environmental goals to ensure accountability and measurable outcomes (Widener, 2004).

Green structural capital, which includes the policies, processes, infrastructure, and eco-friendly technologies embedded within the organization to support sustainability practices, can provide the operational foundation for incorporating environmental considerations into day-to-day activities. Sustainability control systems, such as eco-controls, complement these structural assets by enabling organizations to systematically track performance against sustainability objectives. This alignment ensures that the organization's environmental policies and technologies are operationalized effectively, enhancing both strategic coherence and operational efficiency (Journeault, 2016; Asiaei et al., 2022). In a similar vein, green relational capital emphasizes the organization's relationships with external stakeholders, including customers, suppliers, regulators, and community groups. These relationships are increasingly shaped by stakeholder expectations for transparency, environmental accountability, and proactive engagement on sustainability issues. Sustainability control systems enable organizations to meet these expectations by offering credible frameworks for tracking and reporting on environmental performance (Bastini et al., 2022). This enhances stakeholder trust, strengthens the organization's reputation, and aligns external accountability with internal strategic objectives (Burritt & Schaltegger, 2010; Wang et al., 2021).

Thus, overall, organizations with strong GIC are more likely to adopt sustainability control systems as these resources provide the knowledge, structure, and external engagement required to design and implement robust environmental management frameworks (Asiaei et al., 2022). Based on this reasoning, we propose the following hypothesis:

Hypothesis 2: There is a positive association between GIC elements (green human capital, green structural capital, and green relational capital) and sustainability control systems.

2.4 Sustainability control systems and environmental performance

Prior research emphasizes that sustainability control systems are instrumental in driving sustainable organizational capabilities, including sustainable innovation, market orientation, and organizational learning (Bastini et al., 2022). In the same vein, the literature shows that sustainability control systems play a crucial role in addressing the complexities associated with implementing sustainability strategies (Beusch et al., 2022; Passetti et al., 2014; Gond et al., 2012; Jusoh et al., 2023). By aligning strategic objectives with environmental imperatives,

sustainability control systems facilitate informed decision-making and enable firms to effectively respond to sustainability challenges (Wijethilake, 2018).

The integration of sustainability considerations into corporate strategy is positively linked to the adoption of sustainability control systems (Wijethilake et al., 2017). These systems help translate environmental strategies into actionable performance measures, ensuring managerial accountability and financial quantification of environmental impacts (Perego & Hartmann, 2009; Barani et al., in press). Empirical evidence suggests that organizations proactively engaged in sustainability-related initiatives are more likely to implement sustainability management control systems (Pondeville et al., 2013). Hart (1995) further posits that firms with well-established quality management practices are better equipped to adopt pollution prevention measures, reinforcing the role of sustainability control systems in environmental performance. Additionally, entities use strategic boundary systems (Simons, 1995; Widener, 2007) as quality management structures to minimize environmental risks. Kerr et al. (2015) observe that firms leverage sustainability frameworks such as the balanced scorecard and triple bottom line reporting as diagnostic control mechanisms for monitoring sustainability performance, including environmental management outcomes.

Given the escalating challenges posed by environmental change, firms must integrate sustainability control systems thoughtfully to enhance their environmental impact (Ferretti et al., 2024). Sustainability control systems enable organizations to track and evaluate environmental performance systematically, serving as a foundation for data-driven decision-making (Henri & Journeault, 2010). Empirical research confirms the positive impact of sustainability control and its elements, such as eco-controls, environmental performance measurement systems, and environmental management control, on environmental performance (Antonini et al., 2024; Heggen & Sridharan, 2021; Lisi, 2015; Henri & Journeault, 2010). However, despite their recognized importance, many firms still fail to implement comprehensive sustainability control mechanisms to address all dimensions of sustainability (Lueg & Radlach, 2015). Consequently, further research is needed to explore the role of sustainability control systems in shaping environmental performance outcomes.

Although sustainability control systems are an emerging theme in the management control literature (Kuruppu et al., 2024), research in this domain remains fragmented, particularly regarding their impact on performance (Lueg & Radlach, 2015). Joshi and Li

(2016) emphasize the need for empirical studies that examine how sustainability control mechanisms or elements, e.g., eco-controls and sustainability balanced scorecards, translate sustainability strategies into tangible corporate performance improvements. Ditillo and Lisi (2016) further argue that research on sustainability control mechanisms and their strategic role in corporate sustainability initiatives is still underexplored. Furthermore, existing research has primarily focused on the design of sustainability control systems (Johnstone, 2019; Rodrigue et al., 2013; Gond et al., 2012) rather than their direct impact on environmental performance. Additionally, while sustainability research has contributed to a better understanding of corporate environmental strategies, many studies remain conceptual or qualitative, primarily focusing on developed economies (Johnstone, 2021; Beusch et al., 2022). There is still a gap in quantitative, survey-based research, particularly within the Asian and developing economy contexts (Asiaei et al., 2026).

Therefore, this study contributes to the literature by examining the impact of sustainability control systems on environmental performance through the lens of natural resource orchestration theory, which highlights the strategic alignment of environmental resources and capabilities. Given all the foregoing discussions, we hypothesize the following:

Hypothesis 3: *There is a positive association between sustainability control systems and environmental performance.*

2.5 The mediating effect of sustainability control systems

Companies that seek to boost environmental performance must effectively mobilize their resources, particularly those embedded in green human capital, green structural capital, and green relational capital (Martínez-Falcó et al., 2024). However, possessing these resources alone does not necessarily bring about positive environmental outcomes. Instead, organizations require structured mechanisms to channel these resources toward sustainability-driven objectives. We argue that sustainability control systems serve as such mechanisms, ensuring that GIC is strategically deployed to drive environmental performance. For example, green human capital, which consists of employees' knowledge, expertise, and commitment to sustainability, provides the foundation for proactive environmental initiatives (Asiaei et al., 2022). However, without appropriate control structures, such knowledge may remain underutilized or inconsistently applied across the organization. Sustainability control systems

in general, and balanced use of interactive and diagnostic levers of control in particular, bridge this gap by transforming employees' sustainability knowledge into concrete actions, ensuring that their expertise aligns with strategic environmental goals (Henri & Journeault, 2010).

Similarly, green structural capital, comprising an organization's environmental policies, systems, and eco-friendly technologies, requires integration into daily operations to yield tangible environmental benefits (Xi et al., 2024). Sustainability control systems facilitate this integration by offering monitoring tools, performance benchmarks, and accountability frameworks that ensure environmental policies translate into actionable, measurable outcomes (Wijethilake et al., 2018). Without these control mechanisms, green structural capital may remain underleveraged, failing to contribute meaningfully to environmental performance. Green relational capital, which reflects a firm's engagement with environmentally conscious stakeholders, also benefits from sustainability control systems. While strong stakeholder relationships can drive sustainability efforts, they must be systematically managed and aligned with the firm's environmental strategies. Sustainability control systems provide structured communication channels, reporting frameworks, and sustainability-oriented incentive mechanisms, ensuring that relational capital strengthens environmental performance rather than remaining an abstract engagement tool (Burritt & Schaltegger, 2010).

Thus, we propose that sustainability control is the critical enabler that can translate GIC into environmental performance improvements. Without such control mechanisms, the potential benefits of green intellectual capital may remain fragmented and inconsistently applied, leading to suboptimal environmental outcomes. We argue that this rationale aligns with the natural resource orchestration notion (Asiaei et al., 2026) and posit that the strategic mobilization of environmental resources, through appropriate control mechanisms, is necessary to achieve superior environmental performance. Based on this reasoning, we propose:

Hypothesis 4: *Sustainability control systems mediate the relationship between GIC elements (green human capital, green structural capital, and green relational capital) and environmental performance.*

3. Research Methodology

3.1 Sustainability status in the Indian context

India provides a particularly relevant setting for this study because corporate sustainability reporting among large listed firms has moved from largely voluntary disclosure toward a more structured and mandatory reporting regime. In 2021, the Securities and Exchange Board of India (SEBI) introduced the Business Responsibility and Sustainability Reporting (BRSR) framework for listed entities, replacing the earlier Business Responsibility Report with a more detailed format for ESG-related disclosure (SEBI, 2021). The BRSR framework became mandatory for the top 1,000 listed companies by market capitalisation from the 2022–23 financial year, thereby creating a more formal reporting environment for large Indian firms (SEBI, 2021; Garg et al., 2025).

This regulatory setting is directly aligned with the purpose of the present study. The BRSR framework requires firms not only to disclose sustainability-related outcomes but also to demonstrate the policies, management processes, targets, performance monitoring practices, and oversight mechanisms through which responsible business conduct is embedded within the organisation (SEBI, 2021). These requirements have important implications for management accounting and control because they require firms to generate, monitor, verify, and communicate sustainability-related information in a more systematic manner. In particular, the BRSR framework increases the need for internal reporting routines, environmental performance indicators, accountability structures, and control processes that can connect sustainability objectives with operational decision-making.

The environmental dimension of BRSR is especially relevant to this study's focus on environmental performance. Principle 6 of the BRSR framework states that businesses should respect and make efforts to protect and restore the environment. Its essential indicators require firms to disclose information on total energy consumption and energy intensity, water withdrawal and consumption, Scope 1 and Scope 2 greenhouse gas emissions, air emissions, waste generation and management, environmental compliance, and resource efficiency-related practices (SEBI, 2021). These disclosure requirements create pressure for firms to develop the internal knowledge resources and control mechanisms needed to collect environmental data, monitor environmental performance, and support sustainability-related decision-making.

Recent evidence from India also suggests that BRSR reporting has generated substantial variation in environmental disclosures across firms and sectors, reinforcing the need to understand the organisational capabilities and control systems that support environmental performance. For example, analysis of BRSR disclosures submitted by Indian businesses highlights differences in reporting practices across environmental indicators and sectors, including indicators related to greenhouse gas emissions, energy use, and environmental commitments (Garg et al., 2025). This makes India an appropriate context for examining how firms mobilise GIC and sustainability control systems to improve environmental performance under an evolving mandatory sustainability reporting regime.

3.2 Sample and data collection

This study examines firms listed in the NSE 500 index. The NSE 500 was selected as the sampling frame because it provides a broad and economically significant representation of India's listed corporate sector, covering firms across multiple industries and market segments. The index comprises the top 500 companies selected from the eligible universe based on full market capitalisation and average daily turnover, and therefore provides a suitable basis for identifying firms with significant market presence, organisational complexity, and exposure to stakeholder and regulatory expectations (NSE Indices Limited, 2026). Although other broad-based indices, such as those associated with the Bombay Stock Exchange, also represent important segments of the Indian capital market, the NSE 500 was considered appropriate for this study because it offers a diversified and liquid sampling frame of firms that are likely to have more formalised sustainability reporting practices, internal control systems, and environmental management processes.

Building on the Indian sustainability reporting context discussed above, NSE 500 firms provide an appropriate empirical setting for this study because they are large and economically significant listed firms operating under increasing sustainability disclosure expectations. In particular, the BRSR framework requires large listed firms to disclose sustainability-related information, including environmental performance indicators, and this creates a need for internal reporting routines, sustainability-related knowledge resources, and management control processes (SEBI, 2021). Accordingly, NSE 500 firms are suitable for examining how firms develop and use GIC and sustainability control systems to support environmental performance.

Data were collected through a survey distributed to chief financial officers (CFOs) and senior managers of NSE 500 firms. These respondents were selected because they are typically involved in, or have oversight of, financial reporting, sustainability-related disclosures, environmental investments, internal management control systems, and strategic decision-making processes. Therefore, they were considered appropriate informants for assessing GIC, sustainability control systems, and environmental performance at the organisational level. In particular, CFOs and senior managers are well-positioned to understand how sustainability information is generated, monitored, and integrated into internal control and reporting processes. Where applicable, sustainability officers and senior managers with responsibilities related to sustainability reporting, environmental management, or corporate control were also targeted to ensure that responses reflected informed organisational-level knowledge.

Contact information for potential respondents was obtained from publicly available corporate directories and company websites. A total of 565 survey invitations were distributed via email, and 175 usable responses were received, resulting in a response rate of 31%. Data collection took place between April 2023 and August 2023. To improve the response rate, two reminder emails were sent to potential respondents during the data collection period. Participation in the survey was voluntary, and respondents were assured that their responses would remain anonymous and confidential. The questionnaire included an introductory statement explaining the purpose of the research and confirming that the data would be used solely for academic purposes.

The final sample represents multiple industries, enhancing the generalisability of the findings and enabling inter-industry comparisons (Bontis, 1998). The demographic characteristics of respondents, including industry type, workforce size, and gender distribution, are presented in Table 1. Notably, 34.86% of the respondents belong to the manufacturing sector, which is relevant given the environmental pressures and sustainability reporting expectations faced by manufacturing firms in India. To assess potential non-response bias, an independent sample t-test was conducted by comparing early and late respondents. No significant differences were found between the two groups, indicating that non-response bias is unlikely to affect the results.

Table 1: Demographic profile of entity

Profile	Categories	Frequency	Percent	Cumulative percent
Type of the industry	Non-manufacturing	114	65.14%	65.14%
	Manufacturing	61	34.86%	100.00%
Total		175		
No of employees	<100	27	15.43%	15.43%
	100-200	19	10.86%	26.29%
	201-400	15	8.57%	34.86%
	401-600	26	14.86%	49.71%
	>600	88	50.29%	100.00%
Total		175		
Gender	Males	126	72%	72%
	Females	49	28%	100%
Total		175		

3.3 Measures

All constructs in this study were measured using previously validated scales from the literature to ensure reliability and construct validity. The questionnaire was developed based on an extensive review of prior studies on GIC, sustainability control systems, and environmental performance. All items were measured using a seven-point Likert scale ranging from strongly disagree to strongly agree. The full survey, including the items for all variables of interest and their references, is included in the appendix.

Prior to the main data collection, the questionnaire was pre-tested with five academics specializing in management accounting and sustainability research and ten senior managers with experience in sustainability-related practices. The academics were selected based on their expertise in management accounting, sustainability control systems, and survey-based research, while the senior managers were selected because of their practical familiarity with sustainability reporting, environmental management, or internal control processes. The purpose of the pre-test was to evaluate the clarity, relevance, wording, and structure of the questionnaire and to ensure that the items were understandable to respondents in the Indian listed-firm context. The feedback received during the pre-test mainly related to wording clarity, contextual relevance, and the flow of the questionnaire. In particular, some respondents suggested

simplifying technical terms, clarifying sustainability-related wording, and improving the sequencing of questions to make the survey easier to complete. Based on this feedback, minor revisions were made to improve the readability of several items, refine selected terms, and ensure that the questions were interpreted consistently by respondents. No substantive changes were made to the underlying constructs or measurement scales, as all items were adapted from previously validated instruments.

We measure GIC using 14 items adopted from established scales developed by Chen (2008) and Chang and Chen (2012). The construct captures three dimensions: green human capital, green structural capital, and green relational capital. These dimensions were assessed separately to reflect their distinct roles in supporting sustainability initiatives within organizations. Sustainability control systems were measured based on Simons' (1995) levers of control framework, drawing on prior research in sustainability-oriented management control systems (Asiaei et al., 2022b; Wijethilake, 2017). A total of 12 items were used to capture the extent to which organizations integrate sustainability considerations into management control practices through diagnostic and interactive controls. These items reflect practices such as standardized sustainability reporting, environmental management systems, benchmarking, management reviews, environmental and social audits, managerial attention to sustainability practices, managerial interpretation of sustainability-related information, cross-functional meetings, stakeholder exchange, and the use of intranet systems to share sustainability-related knowledge.

Environmental performance, the dependent variable, was measured using a perceptual approach consistent with prior management accounting studies (Asiaei et al., 2022; Henri and Journeault, 2010; Lisi, 2015). A four-item scale adapted from Lisi (2015) was used to assess the extent to which firms comply with environmental regulations, limit environmental impacts beyond compliance, prevent and mitigate environmental crises, and educate employees and the public about environmental issues. These items are reported in the appendix and are consistent with the study's focus on environmental performance. In this study, firm size was measured as a categorical variable based on the number of employees, with firms classified into different size groups. Industry type was also measured categorically according to the industry classification of the sampled firms. In the PLS analysis, these control variables were incorporated as categorical controls.

3.4 Descriptive information and diagnostic tests

To assess potential common method bias, this study employed the full collinearity variance inflation factor (VIF) test proposed by Kock and Lynn (2012). This procedure evaluates both vertical and lateral collinearity and is automatically implemented in PLS-SEM software. A VIF value exceeding 3.30 indicates pathological collinearity and potential common method bias. In this study, all VIF values are below this threshold, indicating that common method bias is not a concern.

To further examine sample representativeness, multigroup analysis (MGA) using partial least squares path modeling (PLS-SEM) was conducted. The sample was divided into early and late response groups based on the timing of survey submission. MGA is a non-parametric significance test that compares group-specific path coefficients based on bootstrapping results. Differences between groups are considered significant when the p-value is below 0.05 or above 0.95 (Henseler et al., 2009; Sarstedt et al., 2011). The results indicate no significant differences between early and late respondents for the main constructs, further confirming the absence of non-response bias.

4. Data Analysis

PLS simultaneously estimates the measurement model and the structural model (Hair et al., 2025). Typically, the PLS model is analyzed and interpreted in two stages: first, assessing the reliability and validity of the measurement model, and then assessing the structural model (Hair et al., 2017; Hulland, 1999). This sequence ensures that the measures of the latent variables (constructs) are reliable and valid before attempting to draw conclusions about the nature of the latent variable relationships (Hair et al., 1998; Hulland, 1999). The measurement model defines the relationships between manifest items and the unobserved latent constructs they represent (Hall, 2008). Also, the structural model depicts the interrelationships between latent variables. In addition, PLS-SEM takes advantage of the confirmatory feature of the research model and permits the presence of a large number of variables (Wold, 1980). With a hierarchical structure model and a large number of indicators, constructs, and relationships, PLS is also capable of working with extremely complex models. Furthermore, PLS is effective at modelling higher-order constructs. Additionally, PLS permits the flexible treatment of more complex model elements, such as mediating and moderating variables (Hair et al., 2011). We use PLS for data analysis by applying SmartPLS, version 4. Furthermore, we analyze the data

according to the new guidelines presented by Hair et al. (2019). In this regard, the first stage entails evaluating the measurement model to examine the constructs' reliability and validity, followed by the second step, which entails assessing the structural model to test the hypotheses.

4.1. Assessing reflective measurement models

In the first phase of evaluating a reflective measurement model, the indicator's loadings must be determined. Loadings greater than 0.70 are recommended, as they indicate that the construct accounts for more than half of the variance in the indicator, indicating acceptable item reliability. Typically, composite reliability (Joreskog, 1970) is utilized to ascertain the internal consistency reliability during the second stage. Higher levels of dependability are typically associated with greater values. For instance, reliability values between 0.60 and 0.70 are considered "acceptable in exploratory testing," whereas values between 0.70 and 0.90 are "satisfactory to good." Cronbach's alpha is an alternative measure of internal consistency that employs the same thresholds as composite reliability but yields inferior results.

The reflective measurement model was assessed in terms of indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Indicator reliability was examined through outer loadings. As shown in Tables 2 and 3, all indicator loadings exceeded the recommended threshold of 0.70, indicating that each item contributed adequately to its respective construct. Although a small number of indicators, such as GHC05 (0.701) and EP02 (0.729), were relatively close to the threshold, they were retained because their loadings remained acceptable and their inclusion did not compromise construct reliability or validity. Retaining these items also helped preserve the conceptual domain of the constructs.

Internal consistency reliability was assessed using Cronbach’s alpha and composite reliability. All constructs exceeded the recommended cut-off values, indicating satisfactory reliability. Convergent validity was evaluated using the average variance extracted (AVE), which reflects the extent to which a construct explains the variance of its indicators. As reported in Tables 2 and 3, all AVE values were above the recommended threshold of 0.50, confirming adequate convergent validity. Among the first-order constructs, EP showed the lowest AVE value (0.6). However, this value remains above the recommended minimum level of 0.50, indicating that the construct still explains more than half of the variance in its indicators and therefore demonstrates acceptable convergent validity. Because EP also showed acceptable indicator loadings, Cronbach’s alpha, and composite reliability, no item removal was considered

necessary. Discriminant validity was assessed using the heterotrait-monotrait ratio of correlations (HTMT), following Henseler et al. (2015), who proposed HTMT as a more reliable criterion than the Fornell-Larcker criterion. The HTMT results indicated that the confidence intervals did not include 1, confirming that each construct was empirically distinct from the others.

Furthermore, GIC was modelled as a reflective second-order construct composed of three first-order dimensions: Green Human Capital, Green Structural Capital, and Green Relational Capital. As shown in Table 3, the loadings of these dimensions on the second-order construct were all above the recommended threshold, and the AVE, composite reliability, and Cronbach's alpha values also met acceptable standards. These findings provide further support for the reliability and validity of the higher-order measurement model. Overall, the results reported in Tables 2 and 3 support the adequacy of the reflective measurement model for both the first-order and second-order constructs.

Table 2 Results Summary for Reflective Measurement Models

Latent Variable	Indicators	Convergent Validity		Internal Consistency Reliability		Discriminant Validity
		Loadings	AVE	Composite Reliability	Cronbach's Alpha	HTMT confidence interval does not include 1
		>0.70	>0.5	>0.6	>0.6	
Green Human Capital	GHC01	0.844	0.656	0.905	0.867	Yes
	GHC02	0.860				
	GHC03	0.804				
	GHC04	0.831				
	GHC05	0.701				
Green Structural Capital	GSC01	0.783	0.664	0.908	0.872	Yes
	GSC02	0.746				
	GSC03	0.875				
	GSC04	0.829				
	GSC05	0.835				
Green Relational Capital	GRC01	0.787	0.725	0.887	0.808	Yes
	GRC02	0.874				
	GRC03	0.889				
Sustainable Management Control Systems	SCS01	0.807	0.710	0.967	0.963	Yes
	SCS02	0.878				
	SCS03	0.868				
	SCS04	0.857				
	SCS05	0.798				

	SCS06	0.749				
	SCS07	0.865				
	SCS08	0.884				
	SCS09	0.885				
	SCS10	0.889				
	SCS11	0.847				
	SCS12	0.769				
Environmental Performance	EP01	0.796	0.600	0.857	0.778	Yes
	EP02	0.729				
	EP03	0.820				
	EP04	0.751				

Table 3 Results Summary for Reflective Measurement Models (Second-order factors)

Latent Variable	Factors	Convergent Validity		Internal Consistency Reliability		Discriminant Validity
		Loadings	AVE	Composite Reliability	Cronbach's Alpha	HTMT confidence interval does not include 1
		>0.70	>0.5	>0.6	>0.6	
Green Intellectual Capital	Green Human Capital	0/921	0.544	0.939	0.929	Yes
	Green Structural Capital	0/938				
	Green Relational Capital	0/798				

Note: The reported loadings represent the loadings of the lower-order dimensions on the higher-order construct. Cronbach's alpha, rho_C, and AVE for Green Intellectual Capital are reported directly from the SmartPLS construct reliability and validity output for the higher-order construct.

4.2. Assessing structural models

The structural model was assessed using R^2, f^2, and Q^2. The R^2 value indicates the proportion of variance in an endogenous construct explained by its predictor constructs and thus reflects the model's explanatory power. According to prior PLS-SEM guidelines, R^2 values of 0.75, 0.50, and 0.25 can be interpreted as substantial, moderate, and weak, respectively (Henseler et al., 2009). In this study, the R^2 values were 0.403 for Sustainability Control Systems and 0.313 for Environmental Performance. This indicates that the model explains 40.3% of the variance in sustainability control systems and 31.3% of the variance in EP. These results suggest that the model has moderate explanatory power for sustainability control systems and weak-to-moderate explanatory power for EP. This further implies that GIC is an important driver of sustainability control systems, whereas EP is likely influenced not only by the focal constructs but also by other organizational and contextual factors not included in the model. This interpretation is consistent with prior studies showing that green intellectual resources

contribute to environmental outcomes through complementary organizational mechanisms. For example, prior research has shown that GIC improves environmental outcomes through environmental management accounting, ambidextrous green innovation, and environmental performance measurement systems, suggesting that environmental performance is shaped by multiple interrelated drivers rather than a single direct path (Asiaei et al., 2021; 2022a; 2022b).

In addition, the f^2 effect size was used to assess the individual contribution of each predictor to the R^2 value of the endogenous construct. Following Cohen's guideline, f^2 values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively (Cohen, 1988). The results show that Green Intellectual Capital has a large effect on Sustainability Control Systems ($f^2 = 0.676$), indicating that it is a substantively important driver of firms' sustainability-oriented control systems. By contrast, the effects of Green Intellectual Capital on Environmental Performance ($f^2 = 0.085$) and Sustainability Control Systems on Environmental Performance ($f^2 = 0.061$) are small. Although these effects are modest, they remain meaningful, as environmental performance is a complex outcome that is typically influenced by multiple internal and external factors. Thus, the relatively small effect sizes suggest that other variables may also play an important role in explaining firms' environmental performance. Moreover, Q^2 was used to evaluate the predictive relevance of the model. Since all Q^2 values were greater than zero, the model demonstrates adequate predictive relevance (Geisser, 1974; Stone, 1974).

4.2.1. Model's fit (SRMR)

The model and its fitness are determined by using the standardized root mean square residual (SRMR) in this study. The root mean square difference between actual correlations and model-implied correlations is known as the SRMR. A value of zero indicates perfect fit since the SRMR is an absolute fit measure (Hu and Bentler, 1998). According to Hu and Bentler (1998), the SRMR value should be less than 0.10; the value in this research (0.086) is less than 0.10.

4.2.2. Hypotheses testing

As previously mentioned, the statistical approach used in this work is structural equation modelling, which uses the structural equation model's fitness to assess the research hypotheses. The path coefficients are produced in order to investigate the hypotheses, and the significance of these coefficients is assessed using t-test statistics. The path and path coefficient of the target

are significant at the 95% confidence level if the t-value of the test is larger than 1.96 (the crucial value at the level of 0.05).

Figure 2 depicts the results of fitting the research model, which are summarized in Table 4.

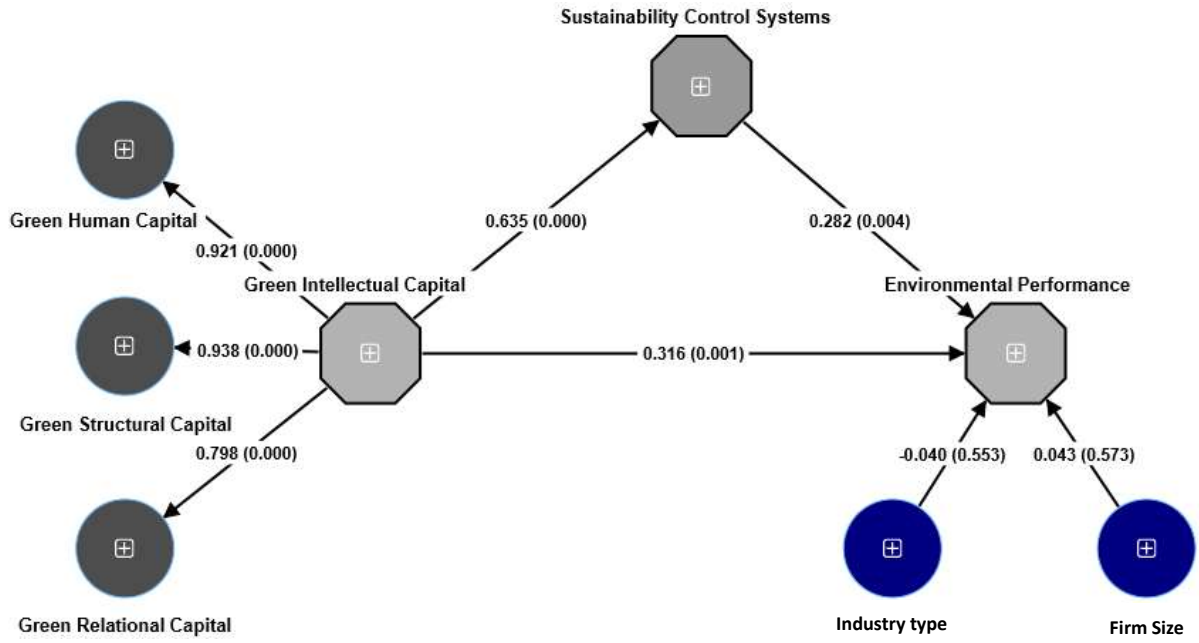

Figure 2: Assessment of the structural model

The structural model results provide support for the hypothesized relationships. As shown in Table 4, GIC has a positive and significant effect on EP ($\beta = 0.316$, $p = 0.001$), thereby supporting H1. Likewise, GIC has a positive and significant effect on Sustainability SMCS ($\beta = 0.635$, $p < 0.001$), supporting H2. In addition, SMCS positively and significantly affects EP ($\beta = 0.282$, $p = 0.004$), supporting H3. With respect to the control variables, neither industry type nor firm size showed a statistically significant effect on environmental performance. Specifically, industry type was not significant ($\beta = -0.040$, $t = 0.594$, $p = 0.553$), and firm size was also not significant ($\beta = 0.043$, $t = 0.564$, $p = 0.573$). These findings suggest that, within the present sample of NSE 500 firms, differences in environmental performance are more strongly explained by the focal theoretical constructs, namely GIC and sustainability control systems, than by broad firm-level characteristics such as industry classification or number of employees. However, given that prior studies often identify firm size and industry sensitivity as relevant factors in environmental performance, this result is further discussed in Section 5.

To test the mediating role of SMCS, the specific indirect effect of GIC on EP through SMCS was examined. As reported in Table 5, the indirect effect is positive and significant (β = 0.179, p = 0.005). Because both the direct effect of GIC on EP remains significant (β = 0.316, p = 0.001) and the indirect effect through SMCS is also significant (β = 0.179, p = 0.005), the results indicate partial mediation rather than full mediation. This suggests that GIC enhances environmental performance both directly and indirectly through its positive influence on sustainability control systems.

Overall, the mediation findings imply that SMCS serves as an important explanatory mechanism linking GIC to EP, while not fully accounting for that relationship. In other words, part of the effect of GIC on environmental performance operates through the adoption and use of sustainability-oriented control systems, whereas another part remains direct.

Table 4 Path Coefficients

Hypothesis	F2	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	P values	Significance (p < 0.05)?
Green Intellectual Capital -> Sustainability Control Systems	0/676	0.635	0.639	0.049	0.000	Yes
Green Intellectual Capital -> Environmental Performance	0/085	0.316	0.318	0.096	0.001	Yes
Sustainability Control Systems -> Environmental Performance	0/061	0.282	0.286	0.097	0.004	Yes
Industry type -> Environmental Performance	-	*-0.040*	*-0.041*	*0.067*	*0.553*	*No*
Fiem Size -> Environmental Performance	-	*0.043*	*0.040*	*0.076*	*0.573*	*No*

Table 5 Specific Indirect Effects

Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	P values	Significance (p < 0.05)?
Green Intellectual Capital -> Sustainability Control Systems -> Environmental Performance	0.179	0.182	0.063	0.005	Yes

5. Discussion and conclusion

5.1 Discussion of key findings

This study examines how GIC contributes to environmental performance through the mediating role of sustainability control systems. Drawing on the natural resource orchestration perspective, the findings indicate that environmental capabilities alone are insufficient to generate sustainability outcomes unless they are effectively mobilized through appropriate organizational mechanisms (Wats et al., 2025). The results demonstrate that firms with stronger

green knowledge resources are more likely to implement sustainability control systems, which in turn translate these resources into measurable environmental performance improvements.

The results confirm that GIC plays an important role in supporting environmental performance. Consistent with prior research, organizations that possess strong green knowledge resources are better positioned to integrate sustainability considerations into their strategies and operations (Chen, 2008; Chang & Chen, 2012; Cai et al., 2026). In particular, the findings highlight the importance of green human capital, suggesting that employees' environmental expertise, sustainability awareness, and problem-solving capabilities are critical for embedding sustainability practices within organizational decision-making. These capabilities enable firms to identify environmental risks, implement sustainability initiatives, and align operational activities with environmental objectives (Asiaei et al., 2026).

The study further shows that firms with stronger GIC are more likely to adopt sustainability control systems. This finding suggests that green knowledge resources encourage organizations to formalize sustainability governance through structured management control mechanisms (Martínez-Falcó et al., 2025). In particular, green structural capital, such as sustainability-oriented policies, internal reporting systems, and organizational routines, provides the institutional foundation for integrating sustainability into management control processes. At the same time, green relational capital facilitates collaboration with external stakeholders, including regulators, suppliers, and investors, which further reinforces the adoption of sustainability-oriented control practices.

Most importantly, the findings demonstrate that sustainability control systems partially mediate the relationship between GIC and environmental performance. This result provides a more nuanced understanding of how green knowledge resources generate environmental outcomes. From a resource-based and intellectual capital-based perspective, GIC represents a valuable resource base consisting of employees' environmental expertise, sustainability-oriented organizational routines, and relationships with environmentally oriented stakeholders. However, from a natural resource orchestration perspective, the value of these resources depends on how they are structured, bundled, and leveraged within the organization (Asiaei et al., 2026). The significant path from GIC to sustainability control systems indicates that firms with stronger green knowledge resources are more likely to develop the control mechanisms needed to coordinate sustainability-related action. The significant path from sustainability

control systems to environmental performance further suggests that these control mechanisms help translate green knowledge resources into environmental outcomes. In this process, diagnostic controls support the monitoring of environmental objectives and performance indicators, while interactive controls encourage managerial dialogue, learning, and strategic adaptation around sustainability challenges (Zoni & Wainer Bustamante, 2025). The partial mediation finding also suggests that GIC contributes to environmental performance both directly and indirectly through sustainability control systems.

The non-significant effects of firm size and industry type provide an additional contextual insight. Although these structural characteristics may influence environmental performance because they shape organizational resources, visibility, and environmental exposure (Aldrich & Auster, 1986), empirical evidence remains mixed. Asiaei et al. (2022a) similarly reported non-significant effects of both firm size and industry type on environmental performance among publicly listed firms, while Sancha et al. (2023) found that neither firm size nor industry type significantly explained environmental performance across 430 US and European firms. In contrast, Abdel-Maksoud et al. (2021) identified a significant industry effect on operational environmental performance among UK manufacturers, suggesting that industry characteristics may become more salient where sectors differ substantially in their environmental exposure. In the present study, the sample comprises NSE 500 firms, which are economically significant listed entities exposed to broadly similar sustainability reporting and environmental accountability expectations under India's evolving BRSR framework (SEBI, 2021). This relative institutional and organizational homogeneity may reduce the explanatory power of broad structural characteristics such as firm size and industry type. Hence, within this sample, environmental performance appears to be shaped more by firms' internal green knowledge resources and sustainability control systems than by these structural characteristics.

5.2 Theoretical implications

This study contributes to the sustainability accounting and management control literature in several important ways. First, it extends the literature on GIC by shifting attention from the mere possession of environmental knowledge resources to the mechanisms through which these resources are effectively mobilized within organizations. While prior research has shown that GIC can support environmental performance (Chen, 2008; Chang & Chen, 2012), less attention has been given to how these resources can be translated into desirable outcomes

through management control systems. By demonstrating that sustainability control systems mediate the relationship between GIC and environmental performance, the study highlights the importance of managerial orchestration in translating environmental knowledge into concrete organizational outcomes.

This study also contributes to the emerging literature on sustainability-oriented management control systems. Previous studies have examined specific mechanisms such as environmental management accounting, environmental performance measurement systems, or green innovation as channels through which GIC influences organizational outcomes (Asiaei et al., 2022a, 2022c, 2023a). In contrast, the present study focuses on sustainability control systems grounded in Simons' levers of control framework, thereby shifting the emphasis from environmental measurement mechanisms to broader managerial control processes that guide strategic attention, organizational learning, and sustainability control systems (Müller et al., 2025). In doing so, this study provides new empirical evidence that sustainability control systems function as a key organizational mechanism through which firms translate GIC into improved environmental performance.

Moreover, this study advances the natural resource orchestration perspective (Asiaei et al., 2022a) by showing how the structuring, bundling, and leveraging of green knowledge resources occur through sustainability control systems. The findings suggest that GIC provides the green resource base, while sustainability control systems provide the managerial mechanism through which these resources are coordinated and deployed. In this sense, green human capital, green structural capital, and green relational capital reflect the resources that firms structure and bundle, whereas sustainability control systems enable firms to leverage these resources through diagnostic and interactive control processes. Diagnostic controls help firms translate environmental objectives into targets, indicators, monitoring routines, and accountability mechanisms. Interactive controls, in turn, support communication, learning, stakeholder engagement, and strategic adaptation around environmental priorities (Wijethilake et al., 2017). By empirically demonstrating that sustainability control systems mediate the relationship between GIC and environmental performance, the study explains how natural resource orchestration operates through Simons' levers of control framework. This provides a clearer theoretical explanation of how firms convert green knowledge resources into environmental performance outcomes.

The study also provides more specific insights into how firms in emerging economies respond to increasing environmental accountability pressures. In the Indian context, the BRSR framework requires large listed firms to disclose environmental information related to areas such as energy use, emissions, water, waste, and environmental compliance. These requirements place pressure on firms not only to disclose environmental outcomes but also to develop internal knowledge resources, reporting routines, and control systems that support reliable sustainability-related decision-making. The findings suggest that firms with stronger GIC are better positioned to develop sustainability control systems, and that these systems help translate internal environmental capabilities into improved environmental performance. Thus, the study shows that, in emerging economies with evolving sustainability reporting requirements, environmental accountability depends not only on external disclosure mandates but also on firms' internal capacity to orchestrate green knowledge resources through structured control systems.

5.3 Practical implications

The findings of this study provide several important implications for firms and managers seeking to improve environmental performance. First, the results suggest that investing in green knowledge resources alone is insufficient unless these resources are effectively integrated into organizational decision-making processes (Asiaei et al., 2026). Firms should therefore ensure that environmental knowledge, employee expertise, sustainability-oriented routines, and stakeholder relationships are supported by structured sustainability control systems. By embedding sustainability objectives within diagnostic and interactive control processes, firms can better coordinate sustainability initiatives, monitor environmental outcomes, and align operational activities with broader environmental strategies (Fagerlin et al., 2026).

The findings also highlight the importance of developing management control mechanisms that translate sustainability capabilities into improved environmental outcomes. Firms that possess strong green human capital, green structural capital, and green relational capital should formalize these capabilities through sustainability-oriented management control practices. In particular, sustainability-focused performance indicators, internal reporting routines, management reviews, cross-functional sustainability meetings, and stakeholder engagement processes can help firms ensure that environmental objectives are consistently integrated into strategic planning and operational management.

Further, the study provides useful insights for policymakers and regulators, particularly in emerging economies where sustainability reporting requirements are rapidly evolving. Regulatory initiatives such as India's Business Responsibility and Sustainability Reporting framework aim to improve corporate environmental accountability. However, the findings of this study suggest that external reporting requirements alone may not be sufficient to drive meaningful environmental improvements unless firms also develop management control mechanisms capable of implementing sustainability strategies. Policymakers and regulators may therefore consider encouraging firms to strengthen sustainability control systems, environmental data processes, and accountability routines alongside external disclosure requirements.

Finally, the findings offer broader implications for organizations operating in emerging economies facing increasing environmental and stakeholder pressures. In such contexts, firms are often required to respond to evolving sustainability disclosure expectations while also developing the capabilities needed to improve actual environmental performance. Sustainability control systems can serve as an important management control mechanism that helps firms connect external environmental accountability requirements with internal decision-making, monitoring, and learning processes. By integrating GIC with structured sustainability control systems, firms can strengthen environmental accountability, improve the reliability of sustainability-related information, and enhance long-term strategic resilience.

5.4 Limitations and future research

Despite its contributions, this study has several limitations that provide opportunities for future research. First, the data were collected through surveys administered to senior managers and CFOs of listed firms. Although these respondents are well-positioned to provide insights into organizational sustainability practices, reporting processes, and management control systems, relying on this group of respondents may not fully capture the perspectives of other organizational actors involved in sustainability implementation. Future research could adopt a multi-level approach by incorporating responses from sustainability officers, middle managers, and operational employees to gain a more comprehensive understanding of how sustainability control systems are implemented across different organizational levels.

Second, the study focuses on firms operating within a single national context, namely India. While this setting provides a valuable opportunity to examine sustainability control systems in an emerging economy characterized by evolving sustainability reporting requirements, particularly the Business Responsibility and Sustainability Reporting framework, the findings may not be directly generalizable to other institutional environments. Future studies could extend this research by conducting cross-country comparisons between developed and emerging economies or by examining industry-specific dynamics to better understand how institutional conditions influence the relationship between GIC, sustainability control systems, and environmental performance.

This study employs a cross-sectional research design, which limits the ability to draw causal inferences regarding the relationships among the constructs. Longitudinal research designs could provide deeper insights into how GIC and sustainability control systems evolve over time and how these capabilities influence environmental performance in the long term. Additionally, future research could explore interactions between GIC and other organizational capabilities, such as green innovation, digital transformation, environmental management accounting, or sustainability reporting systems, in order to develop a more comprehensive understanding of the factors that drive environmental performance and sustainable organizational outcomes. Future studies could also examine whether green information technology capabilities complement GIC and sustainability control systems in improving environmental performance, as such technologies may help firms translate sustainability knowledge and control information into resource optimization, operational efficiency, and environmental outcomes (Barani, 2026). Future research may further consider the financial and accounting literacy of managers as a complementary capability, because managers with stronger financial knowledge may be better able to interpret sustainability-related cost information, evaluate environmental investments, and connect sustainability control information with broader organizational performance outcomes (Barani et al., 2026).

Declarations

No conflict of interest has been declared by the authors.

The authors acknowledge the use of AI-powered language tools, specifically ChatGPT (GPT-5) and Grammarly, to assist with editing, proofreading, and enhancing the overall language and readability of the manuscript. While these tools were employed to improve grammar, spelling,

summarizing, and clarity, the core content, ideas, and analysis presented in this paper remain entirely the original work of the authors.

The data that support the findings of this study are available from the corresponding author upon request.

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