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Interpretive Structural Modeling of Sustainable Development Management in Science and Technology Parks

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ABSTRACT

From a practical perspective, the concept of sustainable development in science and technology parks refers to establishing an effective balance between the current needs of society and future requirements. On one hand, technology parks function as hubs for the growth of start-ups and the strengthening of technological innovation; on the other hand, their environmental and social responsibilities must be structurally and behaviorally institutionalized at all levels of their activities. Therefore, designing conceptual models to enhance sustainable development management in this domain is of considerable importance. Accordingly, the purpose of this study was to design a sustainable development management model in science and technology parks. The research method was descriptive-causal. In the first phase of the study, an interpretive-structural modeling (ISM) approach was used to design the sustainable development management model in science and technology parks. In the second phase, the designed model was tested using structural path modeling within the PLS framework. Data collection was conducted through two questionnaires, which were distributed among members of the statistical sample after verifying their validity and reliability. The statistical population consisted of all managers of science and technology parks, and the final sample included 181 participants. The findings from the interpretive-structural modeling phase indicate that the conceptual model of sustainable development management in science and technology parks is structured across six levels. The managerial commitment component demonstrated the highest level of influence, whereas innovation and research and development exhibited the greatest level of dependence within the conceptual model. Furthermore, the results of the structural path modeling phase confirmed the significance of all identified relationships and validated the designed model in the studied population.

Keywords: Sustainable Development Management, Science and Technology Parks, Managerial Commitment

Introduction

Sustainable development has increasingly emerged as a central paradigm guiding organizational strategy, national policy, and global governance frameworks. As environmental degradation, resource scarcity, social inequities, and technological disruptions intensify, institutions across sectors have recognized the necessity of integrating sustainability into core management and operational structures. The Sustainable Development Goals (SDGs) adopted by the United Nations present a comprehensive blueprint that has influenced not only governmental action but also corporate governance, higher education, supply chain design, and entrepreneurial ecosystems. However, translating the ambition of sustainable development into actionable managerial models

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remains a complex undertaking, requiring interdisciplinary approaches, innovative mechanisms, and adaptive leadership practices. The management literature has thus increasingly focused on identifying frameworks, organizational capabilities, and stakeholder dynamics that enable institutions to achieve sustainability targets effectively.

Emerging global analyses emphasize that academic research plays a crucial role in clarifying conceptual foundations and implementation pathways for SDG-related strategies. A comprehensive interpretive review of SDG-related scholarship in the management domain highlights that research contributions remain fragmented, with uneven attention to the interactive and systemic nature of sustainable development processes (1). Scholars argue that a deeper understanding is required regarding how organizations translate SDG commitments into practical governance routines, operational mechanisms, and technology-enabled capabilities. Aligning with this perspective, environmental management research proposes the value of empirical models that reduce SDG complexity by identifying key dimensions and decision pathways that organizations can adopt to improve sustainability outcomes (2).

Sustainable development implementation is also profoundly shaped by organizational culture, stakeholder engagement, and the presence of enabling institutional environments. In higher education settings, for example, interdisciplinary analyses reveal that the integration of sustainability principles into institutional management practices is strongly influenced by cultural norms, leadership priorities, and organizational learning capacity (3). Similarly, corporate sustainability studies underscore the significance of engaging diverse stakeholder groups—including employees, communities, investors, and regulatory bodies—to build competitive advantage and legitimacy in markets increasingly oriented toward environmental responsibility (4). In emerging economies, sustainability practices are often mediated by pressures from global value chains, institutional reforms, and public expectations, which shape both opportunities and constraints for organizations seeking to embed sustainability in their operations.

A growing segment of the literature highlights the need for strategic frameworks that help organizations operationalize sustainability holistically. For instance, the development of sustainability-driven oversight mechanisms within modern corporate boards represents a notable governance innovation, enabling firms to monitor sustainability performance and ensure alignment with long-term societal expectations (5). Similarly, parliamentary oversight mechanisms have been identified as essential tools for ensuring accountability in national SDG implementation processes, emphasizing the role of political institutions in promoting transparency and public trust (6).

Moreover, sustainability challenges increasingly intersect with advancements in digitalization and artificial intelligence. Research examining the interaction between machine learning tools and sustainable development initiatives demonstrates substantial potential for enhancing the efficiency, prediction capabilities, and success rate of sustainability projects (7). Artificial intelligence has also been recognized as a transformative enabler across sectors, offering innovative pathways for achieving global sustainability goals through data-driven insights, automated decision systems, and enhanced operational monitoring (8). During the COVID-19 pandemic, AI-driven technologies became critical components of crisis response, revealing the capacity of digital tools to support SDG progress under rapidly changing circumstances (9). Additionally, digitalization has significantly shaped urban sustainability trajectories, with economic analyses demonstrating how digital infrastructure can improve environmental, economic, and social indicators across metropolitan regions (10).

Entrepreneurship research similarly reflects the influence of digital transformation on sustainability-oriented business models. The emergence of digital financial capabilities, fintech governance mechanisms, and anti-money laundering compliance frameworks is increasingly recognized as integral to promoting sustainable entrepreneurship in the digital era (11). Within the context of public knowledge institutions, studies show that ethical values mediate the effectiveness of smart sustainable development initiatives, such as those implemented in next-generation digital libraries (12). Collectively, these insights indicate that the digital transformation of organizational practices is not only altering traditional business processes but also expanding the resource base available for implementing sustainability programs.

From a project management perspective, sustainability initiatives introduce a complex array of value creation requirements, risk considerations, and coordination challenges. Prior research emphasizes that project-based organizations must adopt a systemic view of value creation that aligns ecological, economic, and social imperatives when designing and implementing sustainability projects (13). Understanding the relational dynamics among project stakeholders is especially critical in developing countries, where international consulting agencies and local partners often confront structural inequalities, insufficient regulatory frameworks, and cultural barriers that impede sustainability outcomes (14). To manage these multisectoral challenges effectively, scholars have proposed the adoption of new analytical tools—including sustainability impact analyses and risk-based evaluation models—that enable managers to assess environmental implications, anticipate barriers, and strengthen resilience within sustainable product development cycles (15).

Complementing these developments, strategic models targeting corporate sustainability implementation have sought to integrate life-cycle thinking and triple bottom line principles into SMEs, where resource scarcity and capability constraints are particularly salient (16). Research on sustainable manufacturing similarly identifies a series of operational, technological, and organizational factors that must be harmonized to support long-term sustainability performance across industrial sectors (17). Waste management studies further illustrate this point: a multi-criteria examination of waste-to-energy technologies showed that the selection of environmentally appropriate solutions requires multifactorial decision frameworks that balance ecological impacts, financial viability, and societal priorities in alignment with SDGs (18). In the construction sector, analyses of demolition waste management provide evidence that industry practices are increasingly adapting to SDG-oriented frameworks, supported by both academic insights and evolving industrial norms (19).

Despite the breadth of research on sustainability, many organizations—especially SMEs—continue to face significant obstacles in adopting sustainable development practices. Empirical assessments reveal that resource limitations, market uncertainties, institutional weaknesses, and technological gaps constitute prominent barriers, while management commitment to environmental practices plays a mediating role in overcoming these challenges (20). Comparative analyses suggest that effective sustainability initiatives rely on cultivating organizational competencies and leadership mindsets capable of reconciling short-term operational pressures with long-term sustainability goals. This insight aligns with broader cross-sector findings indicating that management commitment serves as a key determinant of sustainability performance across industries and contexts.

Furthermore, the evolution of sustainability reporting frameworks has amplified expectations for transparency and accountability. Integrative analyses demonstrate the importance of linking reporting mechanisms with SDG frameworks to create meaningful pathways for monitoring organizational progress and communicating sustainability commitments to stakeholders (21). Within capital markets, the role of asset management institutions in directing sustainable investment toward SDG-aligned outcomes has become increasingly pronounced, reshaping investment decision processes and influencing corporate sustainability strategies (22). Similarly, international research highlights that organizational support for sustainability at the national and regional levels varies widely, influenced by cultural norms, governance structures, and economic conditions, as evidenced in the examination of corporate SDG engagement in South Africa (23).

Resource management strategies also constitute a critical dimension of sustainable development implementation. Studies focused on circular economy systems and urban mining reveal that organizations must identify critical success factors—such as technology readiness, regulatory support, and resource recovery maturity—to optimize sustainable resource management and reduce ecological harm (24). In addition, analyses of sustainable product development stress the necessity of systematically assessing environmental risks throughout design and production cycles to minimize negative impacts and ensure alignment with sustainability principles (15).

Education and capacity-building mechanisms play a similarly essential role in embedding sustainable development principles. Empirical studies conducted within management education institutions demonstrate that curriculum design, institutional leadership, and stakeholder engagement significantly influence the integration of sustainability knowledge, shaping the competencies of future managers and organizational leaders (25). These findings underscore the broader need for educational and organizational systems that cultivate sustainability literacy, critical thinking, and multi-stakeholder collaboration.

Finally, the interplay between sustainability oversight, digital innovation, stakeholder engagement, and organizational learning demonstrates that sustainable development is inherently multi-dimensional. It requires interconnected competencies that span governance, technology, human capital, and financial systems. Given the broad array of challenges and opportunities presented in contemporary sustainability research—from digital transformation and circular economy innovations to risk management and stakeholder dynamics—there is a clear need for integrated conceptual models that synthesize managerial, organizational, and technological factors into coherent sustainability management frameworks.

Accordingly, the aim of this study is to develop a comprehensive conceptual model for sustainable development management that incorporates organizational, technological, cultural, and strategic factors influencing sustainability implementation.

Methods and Materials

This study is applied in terms of its objective and descriptive–causal in terms of its methodological approach. The research was conducted in two stages. In the first stage, a sustainable development management model for science and technology parks was designed. In the second stage, the developed model was tested using empirical data.

The statistical population of this study was divided into two groups based on the research stages. In the first stage, experts familiar with the subject matter were selected to assist in designing the research model. These experts possessed the following characteristics:

1. Managers of science and technology parks with more than five years of managerial experience and familiarity with sustainable development management.
2. University faculty members with a track record of teaching and publishing articles in the field of sustainable development management.

To identify these individuals, repeated visits were made to various science and technology parks, and expert profiles were collected from different sources. Based on these procedures and the required criteria, fourteen experts were selected for this stage, including five university professors and nine managers of science and technology parks.

In the second stage, the model was tested using empirical data. The statistical population for this part consisted of all managers at various levels in science and technology parks across the country. According to data from the Ministry of Science, Research, and Technology, there are 54 science and technology parks nationwide. Thus, the total number of managers in the population was estimated to be 324. The sample size was determined using the Krejcie and Morgan table, resulting in a sample of 181 managers. Sampling in this stage was carried out using stratified random sampling.

Two questionnaires were used to collect data. In the first stage, a pairwise comparison questionnaire based on the interpretive structural modeling (ISM) method was used. Since ISM relies on expert judgments, experts determined the influence of each factor on other factors in the model through pairwise comparisons.

In the second stage, a researcher-developed questionnaire was used. This questionnaire consisted of three main sections. The first section provided a brief explanation of sustainable development management in science and technology parks for the respondents. The second section included demographic information. The third section contained the questionnaire items. In the third section, respondents indicated their level of agreement with each statement using a five-point Likert scale ranging from strongly disagree to strongly agree. The validity of the questionnaire was initially assessed through face validity, and after distribution and data collection, the validity of each construct was evaluated and confirmed using the average variance extracted (AVE). Reliability was assessed using Cronbach's alpha coefficient for each main component, and all coefficients indicated acceptable reliability.

For data analysis, interpretive structural modeling (ISM) was employed in the first step to design the sustainable development management model. After designing the model, structural path modeling was conducted using PLS software to test the model.

Findings and Results

In this section, based on the main components of sustainable development management in science and technology parks, the conceptual model was designed using interpretive structural modeling. Pairwise comparison questionnaires were distributed among the same experts from the qualitative stage. In the first step, based on majority opinions, the initial reachability matrix was constructed. This matrix represents the direct relationships between the components of sustainable development management. The initial reachability matrix is shown in Table 1.

Table 1. Initial Reachability Matrix

	SDM1	SDM2	SDM3	SDM4	SDM5	SDM6	SDM7	SDM8
SDM1	0	1	1	1	0	0	0	0
SDM2	0	0	0	1	1	0	0	0
SDM3	0	0	0	0	1	0	0	1
SDM4	0	0	0	0	1	1	0	0
SDM5	0	0	0	0	0	1	0	1
SDM6	0	0	0	0	0	0	1	0
SDM7	0	0	0	0	0	0	0	0
SDM8	0	0	0	0	0	0	1	0

In the next step, the final reachability matrix was calculated. To do this, the initial reachability matrix was first summed with an identity matrix of equal size, and then indirect relationships were computed. The final reachability matrix is presented in Table 2.

Table 2. Final Reachability Matrix

	SDM1	SDM2	SDM3	SDM4	SDM5	SDM6	SDM7	SDM8
SDM1	1	1	1	1	*1	*1	*1	*1
SDM2	0	1	0	1	1	*1	*1	*1
SDM3	0	0	1	0	1	*1	*1	1
SDM4	0	0	0	1	1	1	*1	*1
SDM5	0	0	0	0	1	1	*1	1
SDM6	0	0	0	0	0	1	1	0
SDM7	0	0	0	0	0	0	1	0
SDM8	0	0	0	0	0	0	1	1

The final reachability matrix indicates both direct and indirect relationships. The highlighted values represent indirect relationships.

In the next step, the matrix was partitioned into levels. Variables were divided into reachability and antecedent sets, and level outputs were determined based on the intersection of these sets. Summarized results are presented in Table 3.

Table 3. Final Leveling of Main Components of the Sustainable Development Management Model in Science and Technology Parks

Output	Intersection	Antecedent	Reachability	Symbol	Main Component	Level
SDM7	SDM7	SDM1, SDM2, SDM3, SDM4, SDM5, SDM6, SDM7, SDM8	SDM7	SDM7	Innovation and R&D	First
SDM6	SDM6	SDM1, SDM2, SDM3, SDM4, SDM5, SDM6	SDM6	SDM6	Risk Analysis and Evaluation	Second
SDM8	SDM8	SDM1, SDM2, SDM3, SDM4, SDM5, SDM8	SDM8	SDM8	Supply Chain Sustainability	Second
SDM5	SDM5	SDM1, SDM2, SDM3, SDM4, SDM5	SDM5	SDM5	Reporting and Transparency	Third
SDM3	SDM3	SDM1, SDM3	SDM3	SDM3	Collaboration and Partnership	Fourth
SDM4	SDM4	SDM1, SDM2, SDM4	SDM4	SDM4	Use of Modern Technologies	Fourth
SDM2	SDM2	SDM1, SDM2	SDM2	SDM2	Training and Organizational Culture	Fifth
SDM1	SDM1	SDM1	SDM1	SDM1	Managerial Commitment	Sixth

Based on Table 3, the output of the first level is the main component *Innovation and Research & Development*, which lies at the highest level of the model. The second level includes *Risk Analysis and Evaluation* and *Supply Chain Sustainability*. The third level comprises *Reporting and Transparency*. The fourth level includes *Collaboration and Partnership* and *Use of Modern Technologies*. The fifth level consists of *Training and Organizational Culture*. The sixth and lowest level, representing the most influential component, is *Managerial Commitment*.

In the final step, a diagram was created based on the variable levels and the elimination of indirect relationships, illustrating the conceptual model of sustainable development management in science and technology parks. This model is shown in Figure 1.

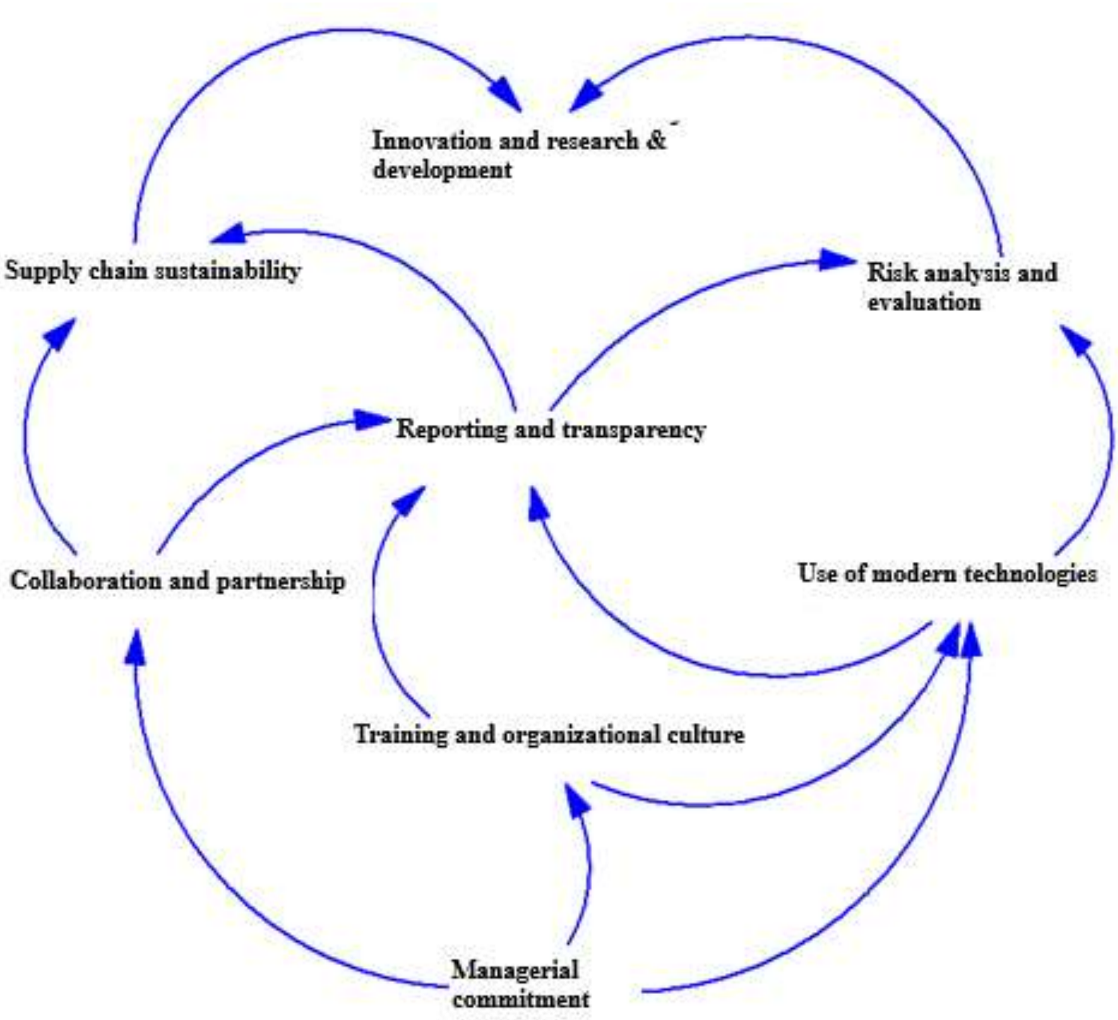

Figure 1. Conceptual Model

The results of interpretive structural modeling in Figure 1 demonstrate that the foundation of sustainable development management in science and technology parks is *Managerial Commitment*, which includes sustainable vision and mission, leadership and role modeling, accountability and responsibility, resource allocation, and networking and collaboration. Positioned at the lowest level, this component is the most influential factor among all components of sustainable development management. Conversely, *Innovation and R&D* represents the most dependent component located at the uppermost level. Moving upward in the model reduces component influence and increases component dependence. The remaining components serve as intermediary factors supporting the transition from managerial commitment to innovation and R&D as the ultimate outcome of sustainable development management in science and technology parks.

In this section, the conceptual model derived from interpretive structural modeling is tested using structural path modeling in PLS software. In structural path models, it is necessary to ensure the validity and reliability of the measurement models before examining the structural model. In the partial least squares approach, factor loadings and their significance, Cronbach's alpha, composite reliability, and average variance extracted (AVE) are used to assess the validity and reliability of the measurement models. The results related to the factor loadings and their significance based on the t statistic are presented in Table 4.

Table 4. Factor Loadings and Their Significance for the Measurement Models

Measurement Model	Path Symbol	Factor Loading	Standard Error	t-value	Significance Level
Managerial commitment	SDM11 ← SDM1	0.949	0.019	49.385	0.000
	SDM12 ← SDM1	0.970	0.012	78.816	0.000
	SDM13 ← SDM1	0.957	0.014	67.616	0.000
	SDM14 ← SDM1	0.931	0.027	34.464	0.000
	SDM15 ← SDM1	0.941	0.025	37.314	0.000
Training and organizational culture	SDM21 ← SDM2	0.977	0.007	137.085	0.000
	SDM22 ← SDM2	0.947	0.024	39.701	0.000
	SDM23 ← SDM2	0.961	0.015	65.211	0.000
	SDM24 ← SDM2	0.970	0.009	113.688	0.000
Collaboration and partnership	SDM31 ← SDM3	0.947	0.022	42.288	0.000
	SDM32 ← SDM3	0.984	0.004	263.745	0.000
	SDM33 ← SDM3	0.942	0.019	49.777	0.000
	SDM34 ← SDM3	0.978	0.007	149.267	0.000
	SDM35 ← SDM3	0.971	0.010	101.485	0.000
Use of modern technologies	SDM41 ← SDM4	0.951	0.022	42.912	0.000
	SDM42 ← SDM4	0.945	0.024	39.025	0.000
	SDM43 ← SDM4	0.961	0.014	68.385	0.000
	SDM44 ← SDM4	0.976	0.006	157.052	0.000
Reporting and transparency	SDM51 ← SDM5	0.926	0.028	33.458	0.000
	SDM52 ← SDM5	0.961	0.013	76.805	0.000
	SDM53 ← SDM5	0.946	0.029	32.262	0.000
	SDM54 ← SDM5	0.981	0.004	230.373	0.000
	SDM55 ← SDM5	0.977	0.007	147.805	0.000
Risk analysis and evaluation	SDM61 ← SDM6	0.963	0.014	71.302	0.000
	SDM62 ← SDM6	0.944	0.017	55.429	0.000
	SDM63 ← SDM6	0.952	0.018	51.592	0.000
	SDM64 ← SDM6	0.970	0.009	105.109	0.000
Innovation and research & development	SDM71 ← SDM7	0.976	0.007	137.860	0.000
	SDM72 ← SDM7	0.939	0.028	34.038	0.000
	SDM73 ← SDM7	0.940	0.027	35.138	0.000
	SDM74 ← SDM7	0.963	0.012	77.867	0.000
	SDM75 ← SDM7	0.929	0.029	32.443	0.000
	SDM76 ← SDM7	0.959	0.016	58.133	0.000
Supply chain sustainability	SDM81 ← SDM8	0.963	0.011	87.160	0.000
	SDM82 ← SDM8	0.939	0.025	37.034	0.000
	SDM83 ← SDM8	0.941	0.026	36.145	0.000
	SDM84 ← SDM8	0.971	0.009	113.708	0.000

Empirically, in assessing factor loadings, values less than 0.30 are considered weak and unacceptable; loadings between 0.30 and 0.50 are regarded as weak but acceptable; and loadings greater than 0.50 are considered appropriate and strong. A factor loading indicates the relationship between an indicator (observed variable) and its main component (latent variable). The results in Table 6 show that all factor loadings are greater than 0.50, which indicates an appropriate relationship between each main component and its corresponding indicators. Statistically, at the 95% confidence level, the t-value for each factor loading must be greater than 1.96. The results in Table 4 show that the t-values for all factor loadings are greater than 1.96, indicating that all factor loadings are statistically significant. Accordingly, the relationships between the indicators and their corresponding main components in the measurement models are confirmed. Table 6 presents the values of Cronbach’s alpha, composite reliability, and average variance extracted.

Table 5. Results for Cronbach's Alpha, Composite Reliability, and Average Variance Extracted

Main Component	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Managerial commitment	0.973	0.979	0.902
Training and organizational culture	0.974	0.981	0.929
Collaboration and partnership	0.981	0.985	0.930
Use of modern technologies	0.970	0.978	0.919
Reporting and transparency	0.978	0.982	0.918
Risk analysis and evaluation	0.970	0.978	0.916
Innovation and research & development	0.979	0.983	0.905
Supply chain sustainability	0.967	0.976	0.909

Cronbach's alpha is a traditional index used to examine internal consistency among the indicators of a main component. The minimum acceptable value for this index is 0.70. The results in Table 5 show that Cronbach's alpha for all main components is greater than 0.70, indicating internal consistency among the indicators of each component. Composite reliability is a more recent index than Cronbach's alpha and, similarly, evaluates internal consistency among indicators; however, it incorporates the factor loadings of the indicators as weights when calculating internal consistency. The minimum acceptable value for this index is also 0.70. The results in Table 6 show that composite reliability for all main components is greater than 0.70, confirming internal consistency among their indicators. Average variance extracted (AVE) examines whether each main component can explain at least 50% of the variance of its indicators. Therefore, the minimum acceptable value for AVE is 0.50. The results in Table 5 show that the AVE for all main components is greater than 0.50, indicating acceptable convergent validity for the measurement models.

After ensuring the validity and reliability of the measurement models, the path coefficients related to the effects in the sustainable development management model in science and technology parks can be examined. Figure 2 presents the path coefficients in the form of the structural path model, and Figure 3 shows the corresponding t-values of the path coefficients.

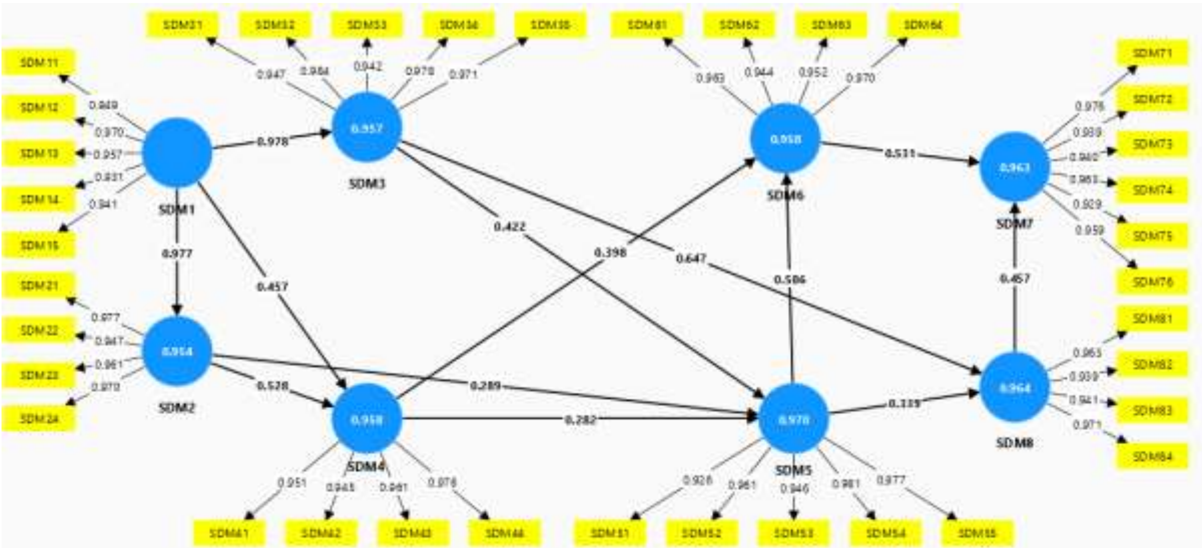

Figure 2. Model with Beta Values

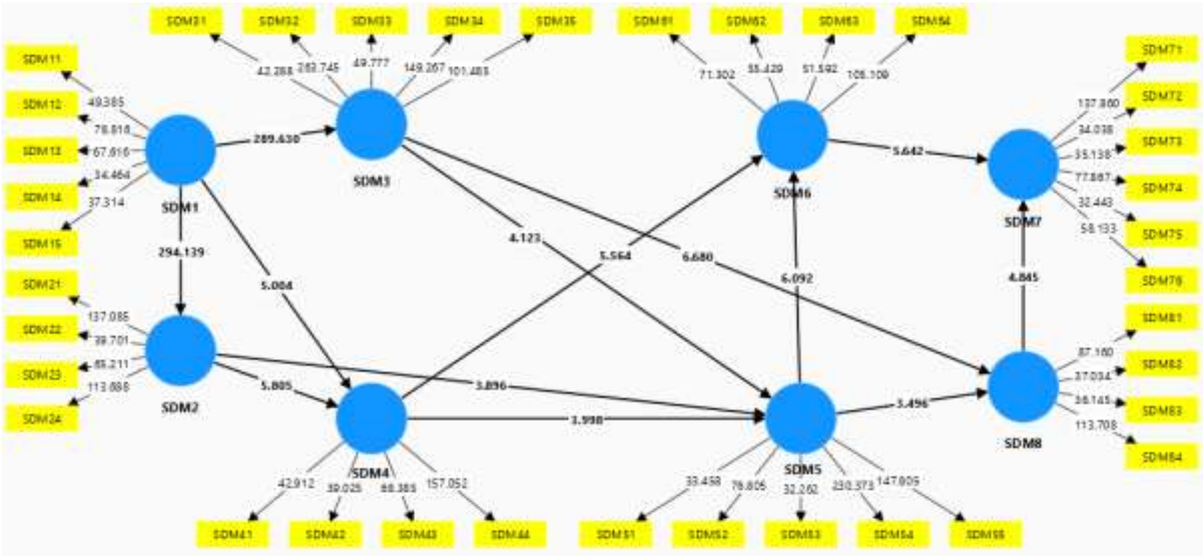

Figure 3. Model with T-Values

A summary of the results related to the path coefficients is presented in Table 6.

Table 6. Summary of Path Coefficients in the Structural Model

Path	Path Symbol	Path Coefficient	Standard Error	t-value	Significance Level
Managerial commitment → Training and organizational culture	SDM1 → SDM2	0.977	0.003	294.139	0.000
Managerial commitment → Collaboration and partnership	SDM1 → SDM3	0.978	0.003	289.630	0.000
Managerial commitment → Use of modern technologies	SDM1 → SDM4	0.457	0.091	5.004	0.000
Training and organizational culture → Use of modern technologies	SDM2 → SDM4	0.528	0.091	5.805	0.000
Training and organizational culture → Reporting and transparency	SDM2 → SDM5	0.289	0.074	3.896	0.000
Collaboration and partnership → Reporting and transparency	SDM3 → SDM5	0.422	0.076	5.564	0.000
Collaboration and partnership → Supply chain sustainability	SDM3 → SDM8	0.647	0.097	6.680	0.000
Use of modern technologies → Reporting and transparency	SDM4 → SDM5	0.282	0.070	3.998	0.000
Use of modern technologies → Risk analysis and evaluation	SDM4 → SDM6	0.398	0.097	4.123	0.000
Reporting and transparency → Risk analysis and evaluation	SDM5 → SDM6	0.586	0.096	6.092	0.000
Reporting and transparency → Supply chain sustainability	SDM5 → SDM8	0.339	0.097	3.496	0.000
Risk analysis and evaluation → Innovation and R&D	SDM6 → SDM7	0.531	0.094	5.642	0.000
Supply chain sustainability → Innovation and R&D	SDM8 → SDM7	0.457	0.094	4.845	0.000

The results related to the path coefficients and their corresponding t-values in Table 6 show that all t-values are greater than 1.96. Accordingly, the relationships derived from the interpretive structural modeling stage and the effects of each main component in the sustainable development management model in science and technology parks are confirmed at the 95% confidence level.

Discussion and Conclusion

The purpose of this study was to design and empirically validate a comprehensive model for sustainable development management in science and technology parks, integrating organizational, technological, cultural, and strategic determinants. The results obtained from both the interpretive structural modeling and PLS-based structural path analysis demonstrate that sustainable development is shaped by a hierarchical sequence of managerial, cultural, collaborative, technological, informational, and evaluative components that ultimately converge in innovation and research and development outcomes. These findings resonate with the multidisciplinary understanding of sustainable development presented in the literature and extend previous empirical evidence by demonstrating the systemic interdependencies among sustainability-related dimensions within the specific context of science and technology parks.

A key finding of the study is the central position of managerial commitment as the most influential component, forming the foundation of the sustainable development management model. This finding strongly aligns with studies identifying leadership commitment, strategic alignment, and governance oversight as critical enablers of sustainability implementation. The emergence of sustainability oversight committees within modern board governance structures has been highlighted as an important mechanism for institutionalizing sustainability values and ensuring long-term strategic adherence (5). Similarly, research on SMEs underscores that managerial commitment significantly mediates the ability of firms to overcome barriers and pressures associated with sustainable development implementation (20). These insights from different organizational settings confirm the robustness of our findings: without managerial commitment, sustainability initiatives lack strategic clarity, resource allocation, and accountability structures necessary for continuity and success.

The significant effect of managerial commitment on training and organizational culture—as well as collaboration and partnership—reveals that leadership influences sustainability both directly and indirectly. This relationship is consistent with evidence from interdisciplinary investigations into higher education environments, where organizational culture was found to be a decisive factor in internalizing sustainability principles (3). Studies examining stakeholder engagement in corporate settings further emphasize that empowered leadership fosters inclusive decision-making, strengthens green competitiveness, and mobilizes actors toward shared sustainability outcomes (4). The direct link found in this study between managerial commitment and organizational culture therefore reinforces the argument that cultural transformation is a leadership-driven process essential to enabling sustainable development.

The findings also demonstrate that collaboration and partnership constitute a crucial intermediary mechanism influencing transparency, supply chain sustainability, and innovation outcomes. Extensive research corroborates the importance of network interaction and stakeholder collaboration in managing sustainable development projects, especially in developing countries where institutional constraints often hinder implementation (14). In addition, project management scholarship emphasizes that value creation in sustainability-oriented projects requires coordination among diverse stakeholders to align expectations and resolve tensions between environmental, economic, and social objectives (13). The results of the current study thus provide empirical support for these theoretical claims, highlighting collaboration not only as a normative principle of sustainability governance but also as a functional driver of performance in science and technology park ecosystems.

The study further found that the use of modern technologies significantly improves transparency, risk analysis, and sustainability-related reporting functions. These findings are highly consistent with research demonstrating that digitalization, artificial intelligence, and advanced computational tools enhance predictive capability, monitoring efficiency, and decision-making accuracy in sustainability projects. For instance, machine-learning-enhanced project assessment approaches have been shown to improve the ability of organizations to identify factors influencing project success (7). Similarly, studies on artificial intelligence-driven sustainable development reveal that AI supports SDG achievement by optimizing technical processes and organizational decision systems (8). In urban contexts, digitalization has been found to exert a measurable influence on sustainability indicators, demonstrating how technological adoption contributes directly to environmental and social improvements (10). Thus, the results of this study confirm that technology adoption is central to modern sustainability management, enabling science and technology parks to adopt more data-driven and transparent operational models.

Reporting and transparency emerged as pivotal factors, exerting substantial effects on risk analysis and supply chain sustainability. This is strongly supported by sustainability reporting research emphasizing that effective reporting frameworks improve accountability, stakeholder engagement, and strategic alignment with the SDGs (21). The asset management literature further shows that transparent sustainability metrics enable investors to allocate capital toward sustainable development priorities, demonstrating the broader significance of reporting beyond internal governance (22). Additionally, empirical work has shown that environmental management education benefits from reduced complexity in sustainability models, allowing stakeholders to understand sustainability progress more clearly (2). Our findings suggest that in science and technology parks, transparency plays a similar role: it clarifies sustainability progress, facilitates risk anticipation, and supports supply chain continuity.

The strong influence of risk analysis on innovation and R&D further underscores the strategic relationship between sustainability risk management and long-term competitiveness. Research on sustainable product development proposes risk assessment tools as essential to identifying environmental impacts and ensuring alignment with sustainability goals (15). In industrial contexts, the ability to identify key factors influencing sustainable manufacturing performance has also been shown to improve innovation-driven operational improvements (17). Moreover, research on waste management and circular economy systems highlights how risk-based technology selection supports sustainable technology adoption and reduces ecological burdens (18, 24). Thus, the link in this study between risk evaluation and innovation echoes broader industry trends: organizations that manage sustainability risks effectively are more capable of driving innovation.

The role of supply chain sustainability as a significant predictor of innovation and R&D outcomes reinforces global findings that sustainable supply chain management contributes to organizational resilience, environmental performance, and competitive advantage. Studies analyzing construction and demolition waste management demonstrate how industry-wide sustainability reforms directly support innovation in materials, processes, and lifecycle design (19). Corporate SDG analyses similarly show that sustainable supply chains form an essential component of systemic sustainability engagements across industries (23). Our findings extend this body of knowledge by demonstrating that in science and technology parks, sustainable supply chain mechanisms directly support innovation productivity and R&D capability.

The central position of innovation and research and development as the most affected variable in the model is consistent with the literature emphasizing innovation as both the outcome and catalyst of sustainable development. AI-based entrepreneurship studies highlight how digital financial capabilities and compliance systems drive sustainable innovation in entrepreneurial settings (11). Ethical values in smart sustainable systems similarly influence the innovative potential of digital and knowledge-based organizations (12). Studies on corporate SDG contributions stress that innovation is one of the primary channels through which organizations generate sustainable impact (1). The findings of this study confirm these arguments: innovation is not merely a technological outcome but the cumulative result of well-coordinated managerial, cultural, technological, and operational systems.

Taken together, these findings contribute to the sustainability management literature by providing an integrative model that captures the hierarchical and causal interdependencies of sustainability factors within science and technology parks. The study provides empirical verification for theoretical arguments emphasizing systemic thinking, stakeholder collaboration, and technology-driven transformation in sustainable development processes. Moreover, it highlights that managerial commitment is the necessary starting point for all subsequent sustainability mechanisms—a finding firmly grounded in the sustainability governance literature.

This study, while comprehensive, is limited by its reliance on self-reported data from managers of science and technology parks, which may introduce subjective bias. The sampling frame, although adequate, was restricted to a single national context, limiting cross-cultural generalizability. The interpretive structural modeling approach, by design, incorporates expert judgment, which may be influenced by participants' prior experiences and assumptions. Additionally, the validated model reflects relationships among predefined constructs and may not capture emerging sustainability variables shaped by rapid technological and geopolitical changes.

Future studies could replicate this model across different countries to compare cultural, institutional, and economic influences on sustainable development management. Longitudinal research designs may reveal how relationships among sustainability components evolve over time. Incorporating qualitative methods could provide deeper insights into managerial behaviors, stakeholder negotiations, and organizational decision processes. Future research may also integrate emerging elements such as blockchain governance, climate risk modeling, and regenerative design principles into sustainability management frameworks.

Organizations operating in science and technology parks should prioritize managerial commitment as the foundation for sustainability initiatives. Investments in organizational culture, staff training, and digital transformation can support the transition from policy intention to operational practice. Strengthening collaboration networks, enhancing reporting systems, and implementing robust risk analysis tools will improve sustainability performance and innovation capability. Finally, integrating supply chain sustainability into strategic planning can enhance organizational resilience and support long-term value creation.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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References

1. Berrone P, Rousseau HE, Ricart JE, Brito E, Giuliodori A. How can research contribute to the implementation of sustainable development goals? An interpretive review of SDG literature in management. International Journal of Management Reviews. 2023;25(2):318-39. doi: 10.1111/ijmr.12331.

2. Greenland SJ, Saleem M, Misra R, Nguyen N, Mason J. Reducing SDG complexity and informing environmental management education via an empirical six-dimensional model of sustainable development. Journal of Environmental Management. 2023;344:118328. doi: 10.1016/j.jenvman.2023.118328.

3. Halmaghi EE, Ranf DE, Badea D. Interdisciplinary exploration between organizational culture and sustainable development management applied to the Romanian higher education environment. Sustainability. 2023;15(13):10688. doi: 10.3390/su151310688.

4. Lyulyov O, Chygryn O, Pimonenko T, Kwilinski A. Stakeholders' engagement in the company's management as a driver of green competitiveness within sustainable development. Sustainability. 2023;15(9):7249. doi: 10.3390/su15097249.

5. Suetens D. The rise of sustainability oversight committees as part of modern board governance and oversight: Practical considerations. Journal of Risk Management in Financial Institutions. 2024;17(2). doi: 10.69554/JDTC9291.

6. Tam A. Parliamentary Oversight to Uphold Accountability in the Review Process of Sustainable Development Goals. Journal of the Malaysian Parliament. 2022;2. doi: 10.54313/journalmp.v2i.57.

7. Chen ZJ, Hsieh TS, Mousavi Davoudi SM. Analysis of factors affecting the success of sustainable development projects with the help of machine learning tools. Discrete Dynamics in Nature and Society. 2022;2022(1):1956879. doi: 10.1155/2022/1956879.

8. Kulkov I, Kulkova J, Rohrbeck R, Menvielle L, Kaartemo V, Makkonen H. Artificial intelligence-driven sustainable development: Examining organizational, technical, and processing approaches to achieving global goals. Sustainable Development. 2024;32(3):2253-67. doi: 10.1002/sd.2773.

9. Mhlanga D. The role of artificial intelligence and machine learning amid the COVID-19 pandemic: What lessons are we learning on 4IR and the sustainable development goals. International Journal of Environmental Research and Public Health. 2022;19(3):1879. doi: 10.3390/ijerph19031879.

10. Yang Y, Shen L, Sang M, Ding X. The impact of digitalization on urban sustainable development - An economic perspective. Technological Forecasting and Social Change. 2025;212:124005. doi: 10.1016/j.techfore.2025.124005.

11. Urooj S, Ullah A, Ullah S, Nobanee H. Sustainable Entrepreneurship in the Digital Era: The Role of Digital Financial Capability and Anti-Money Laundering Compliance. Business Strategy & Development. 2025;8(3):e70147. doi: 10.1002/bsd2.70147.

12. Yunus N, Ismail MN. The Mediating Effect of Ethical Values in Smart Sustainable Library Development. Ifla Journal. 2025. doi: 10.1177/03400352251331446.

13. Moreno-Monsalve N, Delgado-Ortiz M, Rueda-Varón M, Fajardo-Moreno WS. Sustainable development and value creation, an approach from the perspective of project management. Sustainability. 2022;15(1):472. doi: 10.3390/su15010472.

14. Dziubaniuk O, Ivanova-Gongne M, Berdysheva E. Challenges of network interaction in managing sustainable development projects in developing countries: case of an international consulting company. Critical Perspectives on International Business. 2022;18(4):546-73. doi: 10.1108/cpoib-08-2020-0115.

15. Schulte J, Knuts S. Sustainability impact and effects analysis-A risk management tool for sustainable product development. Sustainable Production and Consumption. 2022;30:737-51. doi: 10.1016/j.spc.2022.01.004.

16. Hoevenagel MG. A framework for strategic sustainable development implementation by SMEs (Incorporating life cycle thinking and triple bottom line corporate success): Master's thesis, University of Twente; 2022.

17. Kuo YC, Wu YM, Liu YX. Identifying key factors for sustainable manufacturing and development. Review of Integrative Business and Economics Research. 2022;11(1):30-50.

18. Alam S, Rahman KS, Rokonuzzaman M, Salam PA, Miah MS, Das N, et al. Selection of waste to energy technologies for municipal solid waste management-towards achieving sustainable development goals. Sustainability. 2022;14(19):11913. doi: 10.3390/su141911913.

19. Zhang K, Qing Y, Umer Q, Asmi F. How construction and demolition waste management has addressed sustainable development goals: exploring academic and industrial trends. Journal of Environmental Management. 2023;345:118823. doi: 10.1016/j.jenvman.2023.118823.

20. Madrid-Guijarro A, Duréndez A. Sustainable development barriers and pressures in SMEs: The mediating effect of management commitment to environmental practices. Business Strategy and the Environment. 2024;33(2):949-67. doi: 10.1002/bse.3537.

21. Stefanescu CA. Linking sustainability reporting frameworks and sustainable development goals. Accounting Research Journal. 2022;35(4):508-25. doi: 10.1108/ARJ-07-2020-0196.

22. Folqué M, Escrig-Olmedo E, Corzo Santamaría MT. Contribution of sustainable investment to sustainable development within the framework of the SDGS: the role of the asset management industry. Sustainability Accounting, Management and Policy Journal. 2023;14(5):1075-100. doi: 10.1108/SAMPJ-01-2022-0044.

23. Malan D. Corporate support for the SDGs: A South African perspective. The United Nations Global Compact and the Encyclical Laudato Si: Routledge; 2023. p. 98-120.

24. Fatimah YA, Govindan K, Sasongko NA, Hasibuan ZA. The critical success factors for sustainable resource management in circular economy: Assessment of urban mining maturity level. Journal of Cleaner Production. 2024;469:143084. doi: 10.1016/j.jclepro.2024.143084.

25. Yadav A, Prakash A. Factors influencing sustainable development integration in management education: An Empirical Assessment of management education institutions in India. The International Journal of Management Education. 2022;20(1):100604. doi: 10.1016/j.ijme.2022.100604.