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ERP and Artificial Intelligence as Transformative Technologies for SME Sustainability: A Socio-Technical Systems Perspective

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ABSTRACT

Small and medium-sized enterprises (SMEs) continue to struggle to translate sustainability goals into consistent performance outcomes due to fragmented processes, limited digital integration, and organizational constraints. Although digital technologies are increasingly promoted as enablers of sustainability, existing research provides a limited explanation of how enterprise resource planning (ERP) systems and artificial intelligence (AI) interact within SME transformation processes. This study develops a socio-technical model that explains the sequential and interdependent relationships among organizational readiness, ERP institutionalization, and AI-enabled adaptive capabilities in supporting SME sustainability. A systematic literature review (SLR) was conducted to synthesize evidence on sustainability barriers, ERP capabilities, AI capabilities, and socio-organizational conditions. These elements were integrated into a Technology Transformation Model based on ERP–AI capabilities and assessed through a structured expert-based evaluation. The findings indicate that ERP and AI contribute to sustainability through interdependent mechanisms: ERP functions as an integrative infrastructure that enables process coordination and data consistency, while AI builds upon these conditions to support predictive, optimization-driven, and adaptive decision-making. The results suggest that the effectiveness of digital technologies is conditional upon transformation sequencing and organizational readiness rather than inherent to technology adoption alone. This study offers a process-oriented framework to support sustainability planning, the sequencing of digital investments, and policy design for SME development.

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) are a fundamental pillar of the global economy and play a critical role in advancing sustainable development. They constitute the majority of firms worldwide and contribute significantly to employment, productivity, and economic resilience, especially in emerging economies [1, 2]. Their size and systemic relevance make SMEs essential in meeting sustainability goals, including responsible production, environmental performance, and inclusive growth [3-5]. Despite their importance, SMEs face persistent challenges in translating sustainability goals into stable, measurable outcomes.

A substantial body of literature indicates that sustainability challenges in SMEs are structural and multidimensional. Financial constraints, high implementation costs, and uncertainty about returns on sustainability investments limit the intensity of adoption [6-9]. Technological barriers, including low digital readiness, fragmented systems, and limited access to appropriate technologies, constrain process efficiency and environmental performance [10-13]. Organizational challenges, such as weak strategic alignment, informal structures, and limited process formalization, further reduce the scalability and consistency of sustainability initiatives [14-17]. In addition, knowledge-related limitations, including low sustainability literacy and weak learning capability, hinder effective decision-making and adaptive capacity [18-21]. Institutional factors, such as regulatory complexity, weak stakeholder support, and limited inter-organizational collaboration, further constrain the integration of long-term sustainability [22-25]. These barriers interact cumulatively rather than independently, leading to persistent inefficiencies and inconsistent sustainability outcomes [16, 25-27].

In response to these challenges, digital technologies have increasingly been positioned as enablers of sustainability transformation in SMEs. Enterprise resource planning (ERP) systems provide capabilities related to process integration, data standardization, and operational control, enabling improved coordination, traceability, and resource management [28-30]. Artificial intelligence (AI), in contrast, offers advanced analytical capabilities, including pattern recognition, prediction, optimization, and adaptive learning, supporting more proactive and data-driven decision-making [31-33]. Empirical studies suggest that these technologies can improve operational efficiency and sustainability performance when appropriately implemented [34, 35].

However, despite increasing digital adoption, SMEs continue to experience recurring implementation challenges. Advanced technologies such as AI are often introduced without sufficient organizational readiness or a reliable, integrated data infrastructure. Existing studies frequently examine ERP and AI as independent or parallel technological solutions, with ERP research focusing on integration and control, while AI studies emphasize analytics and automation [29, 35, 36]. This separation obscures a critical structural issue: AI applications depend on consistent, integrated data environments, which are typically established through ERP systems, while ERP systems alone are insufficient to support adaptive, learning-oriented decision-making. Consequently, current literature provides a limited explanation of how these technologies interact within a structured sustainability transformation process.

More importantly, prior research often conceptualizes digital transformation as a discrete adoption event rather than a staged, conditional process [37, 38]. In practice, SMEs frequently adopt digital technologies in response to external pressures without sufficient alignment with organizational capabilities, leading to partial implementation, underutilization, and limited strategic impact. These patterns suggest that the effectiveness of digital technologies is not inherent to the technologies themselves, but depends on how they are sequenced and embedded within socio-organizational conditions.

From a socio-technical systems (STS) perspective, organizational outcomes emerge from the interaction between social subsystems (such as leadership, defined as the process of influencing organizational direction; organizational capability, referring to the collective skills and processes that enable organizations to achieve their goals; and decision-making structures, which are the systems that shape how organizational choices are made) and technical subsystems (such as digital infrastructures, defined as the technological backbone supporting digital activities, and analytical tools, which are software or systems supporting data analysis) [39-41]. However, while this perspective provides a strong theoretical foundation, its application in SME sustainability research remains largely technology-neutral, offering a limited explanation of how specific technologies structure transformation processes or interact as distinct capability layers.

This study addresses these limitations by developing a Technology Transformation Model. This model conceptualizes SME sustainability as a structured socio-technical process. It is grounded in STS theory and operationalized through ERP and AI capability layers: socio-organizational conditions serve as the enabling foundation, ERP provides an integrative infrastructure, and AI operates as an adaptive intelligence layer built on ERP-enabled data environments.

The novelty of this study lies in its technology-specific and dependency-based transformation logic. Rather than introducing new constructs, this study redefines how existing constructs interact within the context of SME sustainability transformation. Specifically, ERP and AI are conceptualized as sequentially dependent layers rather than parallel technologies, where the effectiveness of AI depends on ERP-enabled data integration, and ERP effectiveness depends on prior organizational readiness. This dependency-based and threshold-conditioned perspective provides a structured explanation for recurring digitalization challenges and uneven sustainability outcomes in SMEs.

Methodologically, this study uses a systematic literature review (SLR) to synthesize evidence on sustainability barriers, ERP and AI capabilities, and socio-organizational conditions. Based on these findings, a structured expert assessment evaluates the conceptual coherence and practical plausibility of the proposed model.

This study contributes to the literature in three ways. First, it advances STS research by introducing a transformation model that defines the interdependent roles of ERP and AI. Second, it extends SME digital transformation research by shifting from static adoption perspectives to a process-based understanding. Finally, it offers actionable insights for policymakers and practitioners by providing a logic for sequencing digital investments and aligning capabilities to support sustainability.

2. LITERATURE REVIEW

2.1 The nature of sustainability in SMEs

Sustainability in SMEs varies widely in practice and outcomes. This variation reflects SMEs' limited capacity to integrate environmental, social, and economic objectives into core operations [25, 42]. In contrast to large organizations, which may have greater resources, SMEs often face resource constraints, informal structures, and fragmented processes, thereby limiting their ability to translate sustainability initiatives into lasting performance improvements [43, 44]. As a result, sustainability in SMEs is not a stable organizational capability but an emergent outcome shaped by internal conditions, operational practices, and context [45, 46]. Taken together, this view shifts the focus from isolated factors to the structural conditions that shape how sustainability is enacted within the organization.

2.2 Socio-technical systems as an interaction mechanism

The STS perspective explains organizational performance as the result of dynamic interactions between social and technical subsystems. It contrasts this with the effect of individual components [39, 47]. The social subsystem includes organizational readiness, capabilities, leadership, and decision-making structures. The technical subsystem comprises technologies, data systems, and operational processes [41]. Organizational effectiveness emerges from its alignment. Misalignment leads to inefficiencies, underutilization of technologies, and fragmented processes [40]. For SMEs, this perspective is relevant. Digital transformation initiatives often fail to deliver expected outcomes when technological adoption is not supported by organizational conditions and capabilities [48].

2.3 Conceptual positioning toward a dependency-based model

Building on the socio-technical perspective, sustainability transformation in SMEs can be conceptualized as a structured and interdependent process rather than a set of isolated interventions. Organizational readiness functions as a foundational condition that determines the effectiveness of technological systems, while enterprise systems provide the integration layer required for process coordination and data consistency [49]. AI extends this capability by enabling data-driven decision-making, which directly influences sustainability outcomes [50]. This sequential and dependency-based logic suggests that sustainability performance depends on the interaction and ordering of organizational and technological elements, rather than on their independent adoption. This conceptualization provides the basis for developing a model that explains both successful and unsuccessful conditions for transformation in SME sustainability [25, 45].

To operationalise this conceptual positioning, this study adopts an SLR to identify and integrate evidence across sustainability barriers, ERP capabilities, and AI capabilities, forming the basis for the development of a process-based transformation model.

3. METHODOLOGY

3.1 Research design

This study adopts an SLR to develop an integrative understanding of sustainability transformation in SMEs. The review is designed to identify, synthesise, and integrate three interrelated domains: (1) sustainability barriers in SMEs, (2) ERP capabilities in SME sustainability, and (3) AI capabilities in SME sustainability.

The SLR follows PRISMA principles to ensure transparency, replicability, and methodological rigor. Unlike traditional single-theme reviews, this study employs a multi-theme integrative approach to construct a process-based explanation of how SMEs transition from sustainability barriers to digitally enabled sustainability outcomes.

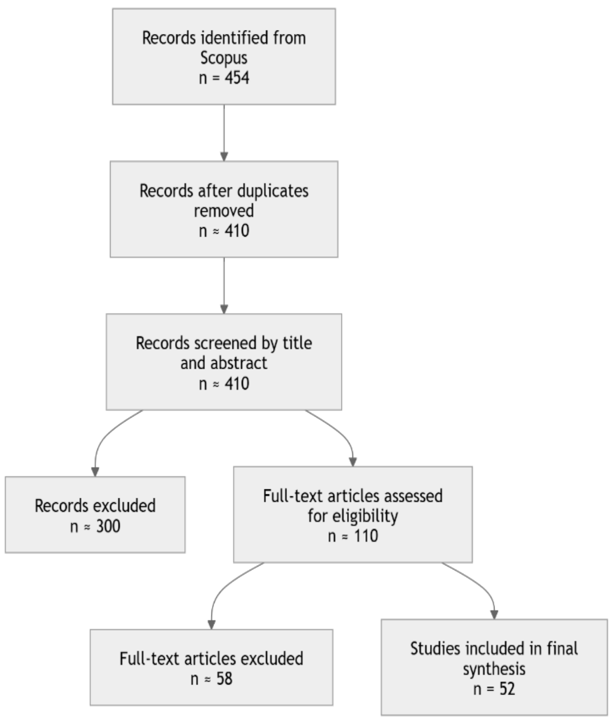

Figure 1. PRISMA flow diagram

3.2 Data source and retrieval procedure

The primary data source was the Scopus database, selected for its comprehensive coverage of peer-reviewed literature in sustainability, information systems, and operations management. Search and retrieval were conducted using Publish or Perish, which facilitated:

(1) structured query execution,
(2) metadata extraction,
(3) and dataset management.

The search was limited to publications between 2020 and 2026, reflecting the most recent developments in ERP and AI adoption in SMEs.

3.3 Search strategy and query formulation

The search was conducted in January 2026 using three separate queries applied to TITLE-ABS-KEY fields in Scopus.

Theme 1: Sustainability Barriers in SMEs

(("sustainability barrier*" OR "barrier* to sustainability" OR "sustainability challenge*" OR "constraint* to sustainability" OR "obstacle* to sustainable practice*") AND ("SME" OR "SMEs" OR "small and medium enterprise*" OR "small business*" OR "medium enterprise*") AND ("sustainability" OR "sustainable development" OR "environmental performance" OR "social performance" OR "economic sustainability"))

Theme 2: ERP and SME Sustainability

(("enterprise resource planning" OR ERP OR "ERP system*" OR "ERP implementation") AND ("small and medium enterprise*" OR SMEs OR "small business*") AND ("sustainability" OR "sustainable development" OR "environmental performance" OR "social performance" OR "economic sustainability" OR ESG))

Theme 3: AI and SME Sustainability

(("artificial intelligence" OR AI OR "machine learning" OR "deep learning" OR "data analytics") AND ("small and medium enterprise*" OR SMEs OR "small business*") AND ("sustainability" OR "sustainable development" OR "environmental performance" OR "social performance" OR "economic sustainability" OR ESG))

All queries were filtered using:

(1) Publication year: 2020–2026
(2) Language: English
(3) Document type: articles and conference papers

The initial search yielded:

(1) 200 records (Theme 1)
(2) 54 records (Theme 2)
(3) 200 records (Theme 3)

Total initial dataset: 454 records.

3.4 De-duplication and data cleaning

All records were exported and merged into a single dataset. Duplicate removal was conducted using:

(1) DOI matching,
(2) title similarity,
(3) author and year verification.

After de-duplication, the dataset was reduced to approximately 410 unique records.

3.5 Screening and selection process

A three-stage screening procedure was applied:

Stage 1: Title Screening
Articles were excluded if they:
(1) did not involve SMEs,
(2) lacked sustainability context,
(3) or were purely technical.
Stage 2: Abstract Screening
Articles were excluded if they:
(1) focused only on large enterprises,
(2) lacked organisational relevance,
(3) or did not relate to ERP, AI, or sustainability barriers.
Stage 3: Full-text Screening
Full-text evaluation ensured:
(1) conceptual relevance,
(2) analytical depth,
(3) and explicit linkage to sustainability outcomes.

3.6 Inclusion and exclusion criteria

Inclusion Criteria
(1) Peer-reviewed Scopus-indexed publications
(2) Explicit SME relevance
(3) Coverage of at least one thematic domain
(4) Linkage to sustainability outcomes.
Exclusion Criteria
(1) Non-English publications
(2) Editorials and non-academic documents
(3) Studies focusing only on large firms
(4) Purely technical studies without organisational context.

3.7 Core article selection criteria

A final filtering stage was conducted to identify the core analytical dataset (52 articles) based on:
(1) Conceptual Relevance: Articles must explicitly address:
- sustainability barriers,
- ERP capabilities,
- AI capabilities in sustainability context.

(2) SME Focus: Priority was given to SME-specific studies or those transferable to SMEs.
(3) Mechanism-Oriented Contribution: Only studies explaining:
- why barriers occur,
- how ERP/AI operate,
- how outcomes emerge were retained.

(4) Analytical Depth: Studies must provide empirical or strong conceptual contributions.
(5) Non-Redundancy: Redundant studies were removed to maintain parsimony.
(6) Integration Potential: Articles contributing to cross-theme integration were prioritised.

3.8 Final dataset composition

Table 1. Systematic literature review (SLR) final dataset

Theme	Initial	Final Core
Barriers	200	20
ERP	54	12
AI	200	20
Total	454	52

These 52 articles constitute the final analytical corpus (Table 1).

3.9 Data extraction and coding

A structured coding framework was applied across all selected articles. Each study was coded into:
(1) Sustainability barriers
(2) ERP capabilities
(3) AI capabilities
(4) Organisational conditions
(5) Sustainability outcomes
Coding was conducted iteratively using constant comparison to ensure consistency and conceptual clarity.

3.10 Reliability and validation

To enhance robustness:
(1) coding was iteratively refined,
(2) discrepancies were resolved through analytical discussion,
(3) categories were stabilised through repeated comparison until saturation.

3.11 Analytical synthesis approach

The synthesis followed a three-step approach:
(1) Within-theme synthesis
- Barrier classification
- ERP capability identification
- AI capability mapping

(2) Cross-theme integration: Linking organisational barriers, ERP systems, and AI capabilities
(3) Model development
- Constructing a process-based transformation framework
- Explaining how SMEs transition from barriers to sustainability outcomes

3.12 Transparency and replicability

To ensure transparency:
(1) full search strings are provided,
(2) selection criteria are explicitly defined,
(3) dataset composition is clearly reported,
(4) and a PRISMA flow diagram (Figure 1) illustrates the selection process.

3.13 Expert-based conceptual assessment

To strengthen the conceptual robustness and practical relevance of the proposed Technology Transformation Model, an expert-based conceptual assessment was conducted following the SLR. This step aimed to evaluate the conceptual clarity, internal logical coherence, and practical plausibility of the model, particularly in representing the interdependent roles of socio-organisational conditions, ERP as an integrative infrastructure, and AI as an adaptive intelligence layer in SME sustainability transformation. This assessment serves as a structured conceptual appraisal rather than empirical validation, providing expert-informed support for the model's integrity and applicability.

3.13.1 Expert panel composition

The expert panel consisted of 10 experts selected using purposive sampling to ensure balanced representation across the socio-technical spectrum of SME sustainability. The panel included:

(1) 3 academic experts in sustainability, STS, and information systems,
(2) 4 SME practitioners with direct experience in ERP and/or AI-enabled operations,
(3) 3 policy and institutional experts involved in SME development and digital transformation programs.

All experts had at least five years of relevant professional experience and demonstrated familiarity with sustainability-oriented digital transformation in SMEs.

3.13.2 Assessment procedure

The assessment employed a single-round structured evaluation, appropriate for theory-driven conceptual model appraisal. Experts were provided with:

(1) A visual representation of the proposed STS–ERP–AI model,
(2) A concise explanation of each subsystem and interrelationship,
(3) An evaluation instrument using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Experts were asked to evaluate the model based on 7 criteria:

(1) Does the proposed model appropriately place socio–organisational readiness as the primary foundation for SME sustainability transformation?
(2) Is the conceptual role of ERP as an integrative infrastructure for process alignment, data consistency, and operational control clearly and logically defined in the model?
(3) Is AI correctly positioned as an adaptive and analytical layer that builds upon ERP-enabled data structures rather than as a standalone technology?
(4) Does the proposed transformation sequence from socio–organisational foundations to ERP adoption and subsequently to AI integration reflect a coherent and theoretically sound logic?
(5) Do the interactions and feedback loops between social and technical subsystems adequately represent core STS principles?
(6) Is the inclusion of external stakeholders and institutional support actors as contextual enablers conceptually relevant for SME sustainability transformation?
(7) Does the model clearly link ERP–AI-enabled transformation to SME sustainability outcomes aligned with the Sustainable Development Goals (SDGs 8, 9, 12, and 13)?

The model was assessed using median and interquartile range (IQR) statistics. A model component was considered validated when:

(1) the median score was ≥ 4.0, and
(2) The IQR was ≤ 1.0, an acceptable consensus.

Qualitative comments from experts were used to refine terminology, clarify feedback loops, and improve the articulation of socio-organisational and technical interactions without altering the model's core structure.

4. RESULTS

4.1 Sustainability barriers in small and medium-sized enterprises

The barriers presented in Table 2 indicate that sustainability challenges in SMEs are not isolated constraints but structurally interconnected limitations spanning financial, technological, organisational, knowledge, and institutional dimensions. Rather than operating independently, these barriers form a reinforcing system in which weaknesses in one domain amplify constraints in others. For example, limited financial capacity restricts technology adoption, while low digital readiness reduces the effectiveness of organisational and managerial improvements. This interconnected structure explains why sustainability initiatives in SMEs often fail to achieve consistent outcomes despite targeted interventions.

Importantly, the presence of cross-cutting systemic barriers suggests that sustainability transformation cannot be addressed through single-dimensional solutions. Instead, it requires coordinated changes across organisational readiness, technological capability, and institutional support. This systemic perspective provides a critical foundation for understanding why fragmented or technology-first approaches frequently result in partial or unsustainable outcomes, thereby reinforcing the need for an integrated socio-technical transformation framework.

Table 2. Sustainability barriers in small and medium-sized enterprises (SMEs)

Barrier Category	Core Issues	Sustainability Consequence	Refs.
Financial	Capital constraints, high investment cost, uncertain returns	Delayed and low-intensity sustainability adoption	[6-9]
Technological	Low digital readiness, fragmented systems, limited technology access	Inefficient resource use and weak environmental performance	[10-13]
Organisational	Weak structure, poor alignment, low process formalisation	Inconsistent and non-scalable implementation	[14-17]
Knowledge-based	Low literacy, limited managerial capability, weak learning systems	Poor decision quality and low adaptability	[18-21]
Institutional	Regulatory complexity, weak stakeholder and network support	Slow adoption and weak institutionalisation	[22-25]
Systemic (Cross-cutting)	Interdependent barriers across organisational and technological domains	Persistent inefficiency and low sustainability integration	[7, 10, 11, 15, 16, 18, 21, 25]

4.2 ERP-related capabilities

Table 3 highlights that ERP capabilities function as a structural foundation that reorganises how processes, data, and operational control are managed within SMEs. Their contribution to sustainability emerges from the system-wide integration and standardisation of activities rather than from isolated functionalities. Importantly, the effectiveness of ERP is conditional, as its benefits depend on the extent to which the system is properly adopted, configured, and embedded into organisational routines. This perspective indicates that ERP primarily acts as an enabling infrastructure that stabilises operations and supports consistent information flows. However, it does not directly generate adaptive or predictive capabilities. Instead, its role lies in creating the necessary conditions for more advanced, data-driven functions. This reinforces the view that ERP should be understood as a foundational layer in sustainability transformation, upon which higher-level analytical and decision-making capabilities can subsequently develop.

4.3 AI-related capabilities

Table 4 shows that AI capabilities extend beyond operational efficiency by enabling predictive, adaptive, and data-driven decision processes within SMEs. Unlike ERP, which primarily stabilises and integrates organisational processes, AI introduces dynamic capabilities that allow firms to anticipate changes, optimise resource use, and continuously refine sustainability strategies. This distinction highlights the complementary but fundamentally different roles of ERP and AI within sustainability transformation.

However, the table also indicates that the effectiveness of AI is conditional and context-dependent. Its contribution relies heavily on the availability of structured, high-quality data and sufficient organisational readiness. Without these prerequisites, AI remains underutilised or fails to deliver meaningful sustainability impact. This reinforces the interpretation of AI as an advanced capability layer that builds upon prior digital and organisational foundations rather than functioning as an independent driver of sustainability.

Table 3. ERP-related capabilities

ERP Capability	Function	Implication	Refs.
Process Integration	Integrates fragmented functions into a unified system	Improved visibility and coordination of resource flows	[51-53]
Data Standardisation	Standardises data structures and transactions	Reliable reporting and traceability	[28, 29, 35]
Operational Control	Enables monitoring and coordination of operations	Reduced inefficiency and waste	[34, 54, 55]
Adoption Readiness	Depends on organisational and user readiness	Limited impact if poorly adopted	[52, 56, 57]
Infrastructure Flexibility	Provides scalable and flexible ERP architecture	Supports digital upgrading in SMEs	[34, 35]
Sustainability Configuration	Aligns ERP with sustainability objectives	Direct support for sustainable operations	[29, 51]
Institutionalisation	Embeds ERP into organisational routines	Enables long-term sustainability impact	[53, 54]

Table 4. AI-related capabilities

AI Capability	Function	Implication	References
Analytics and Pattern Recognition	Identifies patterns and inefficiencies in operational data	Improved resource efficiency and risk identification	[31-33, 58]
Prediction and Forecasting	Supports forward-looking and anticipatory decisions	Reduced waste and improved planning	[38, 59-61]
Optimization and Decision Support	Enhances decision quality and operational optimisation	More efficient use of materials and energy	[33, 36, 62]
Adaptive Learning Capability	Learns from data and improves over time	Continuous performance improvement	[63-65]
Circular Economy Enablement	Supports closed-loop and resource recovery processes	Reduced material waste and improved circularity	[62, 64, 66]
Business Model Support	Enables sustainability-oriented value creation	Enhanced long-term competitiveness	[36, 67, 68]
Adoption and Readiness Conditions	Depends on data quality and organisational readiness	Limited impact under low digital maturity	[37, 38, 69]
Conceptual AI–Sustainability Framing	Provides theoretical basis for AI in sustainability	Strengthens linkage between AI and sustainability outcomes	[58, 63, 65]

4.4 Technology transformation model: Socio-technical structure and component roles

Table 5 presents the structural configuration of the Technology Transformation Model, highlighting how sustainability outcomes emerge from the interaction of distinct yet interdependent subsystems. The model is organised as a layered transformation process, where socio-organisational conditions act as the enabling foundation, ERP establishes the structural and informational infrastructure, and AI introduces adaptive and predictive capabilities. External enablers function as contextual accelerators rather than primary drivers, supporting the transformation process through resources and institutional reinforcement.

This configuration emphasises that sustainability outcomes are not directly generated by technology alone, but arise from the sequential and interdependent activation of these subsystems. The model, therefore, captures a technology-structured transformation logic, in which each layer performs a distinct role while simultaneously enabling the effectiveness of subsequent layers. This perspective provides a coherent explanation of how digital technologies contribute to sustainability in SMEs beyond isolated or parallel adoption approaches. The synthesis of sustainability barriers, ERP capabilities, and AI capabilities provides the structural basis for constructing the Technology Transformation Model.

4.5 Technology transformation model based on ERP–AI capabilities for small and medium-sized enterprises

Figure 2 presents the Technology Transformation Model, which conceptualises SME sustainability as a structured transformation process emerging from the interaction of socio-organisational and technological subsystems.

Table 5. Technology transformation model structure

Subsystem	Components	Role	Refs.
Social–Organisational	Leadership, skills, readiness, sustainability orientation	Foundational condition enabling or constraining technology utilisation	[15, 16, 37, 38]
Technical Foundation (ERP)	Process integration, data standardisation, operational control	Provides structured infrastructure and data consistency	[29, 51, 52, 54]
Advanced Adaptive System (AI)	Analytics, prediction, optimisation, learning capability	Enables adaptive and data-driven decision-making	[31, 33, 36, 62]
External Enablers	Government, institutions, finance, ecosystem support	Supports and accelerates transformation through resources and legitimacy	[8, 24, 25]
Sustainability Outcomes	Economic, environmental, and social performance	Represents the outcome of the transformation process	[28, 61, 63]

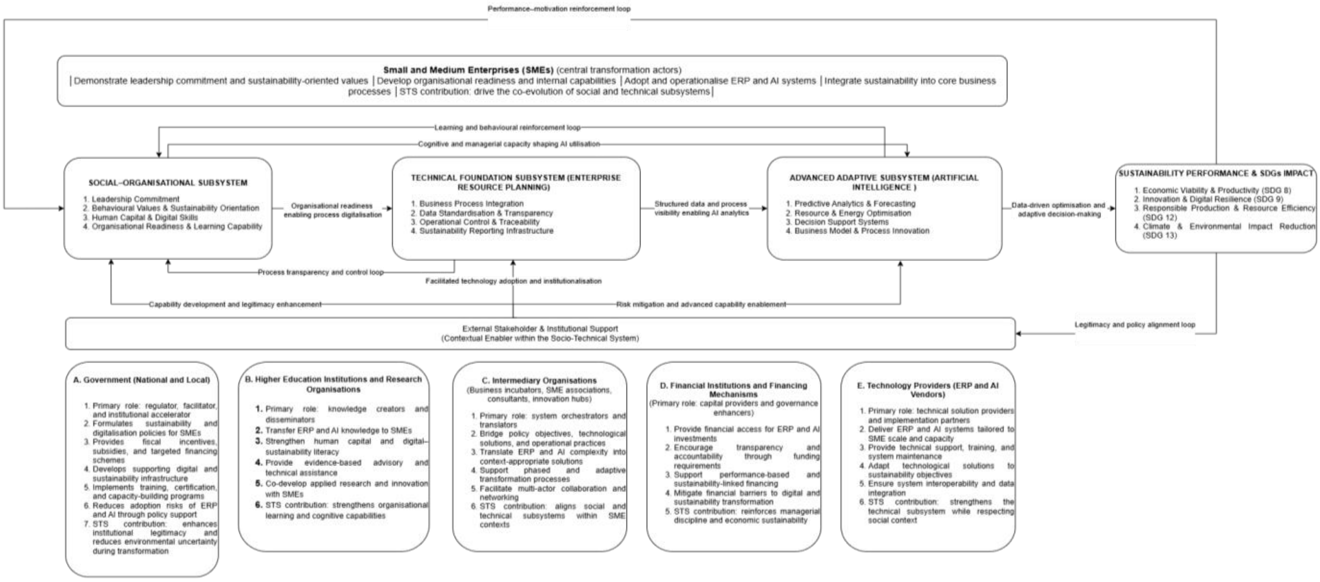

Figure 2. Technology transformation model: A socio-technical systems (STS) perspective on ERP–AI-enabled small and medium-sized enterprises (SMEs) sustainability

The model is organised into three primary layers. The socio-organisational subsystem acts as the enabling condition, shaping organisational readiness, leadership commitment, and capability development required for digital adoption. Building on this foundation, ERP functions as an integrative infrastructure that connects business processes, standardises data, and establishes operational control, thereby creating stable and traceable systems. AI subsequently operates as an adaptive intelligence layer that leverages ERP-enabled data to generate predictive insights, optimise resource allocation, and support dynamic decision-making.

The model emphasises that sustainability outcomes do not arise from isolated technology adoption, but from the sequential activation of interdependent capabilities. ERP provides the structural and informational prerequisites necessary for AI utilisation, while AI extends these capabilities into adaptive and forward-looking sustainability management. This configuration implies that the effectiveness of digital technologies is conditional upon the proper sequencing of transformation stages, where misalignment between organisational readiness, ERP implementation, and AI utilisation may limit the realisation of sustainability outcomes.

In addition, the model incorporates reinforcing feedback loops, including learning, performance, and legitimacy dynamics, which facilitate continuous capability development and institutionalisation over time. External enablers such as government, financial institutions, and technology providers function as contextual accelerators that support resource access and policy alignment, without acting as primary drivers of transformation. Overall, the model captures a technology-structured transformation logic in which sustainability performance emerges from coordinated socio-technical interactions rather than standalone interventions.

4.6 Model assessment results

The expert-based assessment indicates a high level of agreement regarding the conceptual clarity, internal coherence, and practical relevance of the proposed Technology Transformation Model. All evaluation criteria achieved median scores of at least 4.0, with IQR values not exceeding 1.0, suggesting a consistent level of expert consensus across domains (Table 6). The results provide conceptual support for the model's structural logic, particularly the positioning of socio-organisational conditions as the enabling foundation, the role of ERP as an integrative infrastructure, and the function of AI as an adaptive analytical layer. Experts consistently recognised the sequential and interdependent nature of these components, indicating that the transformation pathway is perceived as theoretically sound and practically meaningful.

Table 6. Model assessment results

Feedback Loop	Focus of Validation	Median	IQR	Result
Organisational readiness – technology adoption	Social readiness as a transformation foundation	5.00	1.00	Valid
ERP institutionalisation	ERP as integrative infrastructure	4.00	1.00	Valid
Data enablement	ERP-enabled data for AI use	5.00	0.05	Valid
Adaptive intelligence	AI-driven prediction and learning	4.00	1.00	Valid
Socio-technical learning	Social–technical interaction loops	4.00	1.00	Valid
Institutional support	External stakeholder enabling role	4.00	1.00	Valid
Performance reinforcement	Sustainability outcomes linked to SDGs	5.00	0.05	Valid

Furthermore, the inclusion of feedback mechanisms related to learning, capability accumulation, institutional reinforcement, and performance improvement was assessed as consistent with STS principles. These dynamics reinforce the interpretation of the model as a process-oriented representation of transformation rather than a static configuration of factors. Qualitative feedback was used to refine terminology and clarify the articulation of relationships and feedback loops, without altering the underlying transformation logic. Overall, the findings suggest that the model offers a coherent and contextually relevant representation of ERP–AI-enabled sustainability transformation in SMEs, while remaining a conceptual framework that requires further empirical examination.

5. DISCUSSION

Building on the results of the SLR synthesis and model assessment, the following discussion interprets the findings in relation to prior literature.

5.1 ERP and AI roles: Confirmed functions but repositioned structure

The findings of this study support prior research that identifies ERP and AI as important enablers of sustainability in SMEs. ERP has been consistently associated with process integration, data standardization, and operational control, enabling improved coordination and resource efficiency [29, 34, 52]. AI, in turn, contributes through predictive analytics, optimization, and adaptive decision-making, supporting more proactive sustainability practices [33, 58, 63]. These roles are also reflected in process-oriented studies, where integrated systems and analytical capabilities improve operational sustainability performance [70]. However, existing studies largely treat ERP and AI as parallel or functionally equivalent technologies. This assumption obscures a critical structural distinction. The present findings demonstrate that ERP and AI do not operate at the same analytical level. ERP functions as an infrastructural layer that stabilizes processes and data environments, whereas AI operates as an adaptive layer that depends on these structured conditions. This repositioning shifts the analytical focus from "what technologies do" to "how technologies are structurally organized," providing a more precise explanation of their roles in sustainability transformation.

5.2 From complementarity to conditional dependency

The dominant view in the literature frames ERP and AI as complementary technologies that jointly enhance performance [29, 35]. While this interpretation is not incorrect, it is analytically insufficient. Complementarity assumes co-existence, but does not explain activation conditions. The findings of this study demonstrate that the relationship between ERP and AI is not merely complementary but conditionally dependent. Specifically, AI effectiveness depends on ERP-enabled data integration, while ERP effectiveness depends on socio-organizational readiness. This introduces a directional and staged relationship that is largely absent in prior work. Empirical evidence on digital culture further reinforces this interpretation, showing that technological systems yield outcomes only when aligned with organizational context and behavioral conditions [71]. By converting complementarity into dependency, this study advances the literature from a static to a process-based understanding of digital transformation.

5.3 Organizational readiness as a determinant, not a moderator

Prior studies consistently highlight organizational readiness, leadership, and human capability as important factors in digital transformation [15, 37]. However, these factors are typically treated as contextual variables or moderators. The present findings challenge this positioning by demonstrating that organizational readiness is a determinant that shapes the viability of the entire transformation pathway. This interpretation is consistent with research on organizational sustainability, which emphasizes the role of internal systems, culture, and human resource practices in enabling long-term performance [72]. It is also aligned with conceptual frameworks that identify internal capability alignment as a prerequisite for sustainable SME transformation [73]. The contribution of this study lies in elevating organizational readiness from a supporting factor to a structural prerequisite that conditions both ERP institutionalization and AI effectiveness.

5.4 Threshold logic: Explaining why digital transformation often fails

This realignment of organizational readiness sets the stage for a deeper exploration of one of the central contributions of this study: the introduction of a threshold-based interpretation of digital transformation. Prior research often assumes that technology adoption leads to improved sustainability outcomes, although empirical findings remain inconsistent [7, 16]. The present findings provide a clearer explanation of this inconsistency. Digital technologies do not generate outcomes automatically; they become effective only when minimum organizational and infrastructural conditions are achieved. This threshold logic is consistent with evidence showing that

SMEs face significant challenges in implementing sustainability systems, including reporting, governance, and institutionalization barriers [74]. More importantly, this perspective explains a recurring empirical anomaly: why similar technologies produce divergent outcomes across SMEs. The answer lies not in the technology itself, but in whether the required threshold conditions are met. This reasoning also helps explain the variability reported across the literature, bringing us to the question of transformation sequencing.

5.5 Explaining variability in prior findings through transformation sequencing

The literature on digital transformation in SMEs frequently reports uneven and sometimes contradictory outcomes, particularly in relation to sustainability performance and operational improvement, where similar technologies yield divergent results across contexts [38, 69, 75]. These inconsistencies are commonly attributed to contextual factors such as resource constraints or digital maturity, yet they remain insufficiently explained at a structural level. The findings of this study suggest that such variability is not merely contextual but fundamentally conditioned by transformation sequencing. Specifically, sustainability outcomes depend on whether socio-organisational readiness, ERP integration, and AI capability development occur in an aligned and sequential manner. When this sequence is disrupted, digital technologies operate below their functional potential, resulting in fragmented or unstable outcomes. By introducing sequencing as an explanatory mechanism, this study reframes previously fragmented findings into a coherent transformation logic, shifting the analytical focus from whether digital technologies work to under what conditions and in what sequence they generate meaningful sustainability outcomes.

5.6 Advancing socio-technical systems toward technology-specific modelling

STS theory emphasises that organisational outcomes emerge from the interaction between social and technical subsystems, including organisational capabilities and technological infrastructures [40, 41]. While this perspective has been widely applied in SME sustainability research, its operationalisation often remains technology-neutral, treating the technical subsystem as a broad and undifferentiated category. As a result, prior studies tend to overlook how specific technologies contribute differently within transformation processes, limiting the ability to explain how ERP and AI shape sustainability outcomes in distinct yet interconnected ways. This study extends the STS perspective by introducing a technology-specific and dependency-based interpretation of transformation. ERP is conceptualised as an integrative infrastructure that enables data consistency and process stability, while AI functions as an adaptive layer that builds upon ERP-enabled data environments to support predictive and optimisation-oriented decision-making. This layered configuration suggests that digital transformation in SMEs is not an additive process of technology adoption, but a structured and conditional pathway in which technological effectiveness depends on sequential capability development. By reframing ERP and AI as interdependent rather than parallel technologies, this study provides a more precise explanation of how sustainability outcomes emerge under varying organisational and infrastructural conditions.

6. CONCLUSIONS

This study develops a Technology Transformation Model that conceptualises SME sustainability as a structured socio-technical process shaped by the interaction between organisational conditions, ERP capabilities, and AI-enabled adaptive functions. The findings confirm that ERP and AI contribute to sustainability, while demonstrating that their roles are sequentially interdependent rather than independent. In particular, ERP functions as an integrative infrastructure that enables data consistency and process stability, whereas AI builds on this foundation to support predictive and adaptive decision-making. By introducing a dependency-based and threshold-oriented perspective, the study provides a clearer explanation of how sustainability outcomes emerge and why digital transformation in SMEs often produces uneven results, shifting the focus from isolated technology adoption to structured transformation processes.

This study has several limitations. First, the model is conceptual and derived from systematic literature synthesis combined with expert-based assessment, which does not allow for empirical verification of causal relationships. Second, the expert panel, while diverse, remains limited in size and may not fully capture the heterogeneity of SME contexts across sectors and regions. Third, the study focuses specifically on ERP and AI, which, although representative, may not encompass the full range of digital technologies influencing sustainability transformation. These limitations suggest that the findings should be interpreted as theoretically grounded propositions rather than empirically confirmed relationships.

Future research should focus on empirically examining the proposed transformation logic using longitudinal or process-based approaches to capture the dynamic nature of SME transformation. Expanding the model across different sectors and regional contexts would enhance its generalisability and practical relevance. In addition, integrating other emerging digital technologies and exploring alternative transformation pathways would provide a more comprehensive understanding of digital-enabled sustainability. Ultimately, advancing this line of research will be essential for bridging the gap between conceptual transformation frameworks and empirically grounded insights into how SMEs can effectively achieve sustainable outcomes through structured digital transformation.

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REFERENCES

[1] OECD. (2024). Financing SMEs and Entrepreneurs 2024. OECD Publishing. https://doi.org/10.1787/fa521246-en

[2] Carvajal, A.F., Didier, T. (2024). Boosting SME Finance For Growth: The Case for More Effective Support Policies. Washington, DC: World Bank. https://doi.org/10.1596/42213

[3] Okolo, V.O., Ohanagorom, M.I., Okocha, E.R., Muoneke, O.B., Okere, K.I. (2023). Does financing SMEs guarantee inclusive growth and environmental sustainability in the European Union? Heliyon, 9(4): e15095. https://doi.org/10.1016/j.heliyon.2023.e15095

[4] Nabais, E., Franco, M. (2024). Sustainable development practices in small and medium-sized enterprises: Multiple case studies. International Journal of Organizational Analysis, 32(10): 2494-2516. https://doi.org/10.1108/ijoa-08-2023-3900

[5] Tu, Y.X., Kubatko, O., Melnyk, L., Li, R., Kovalov, B., Yaremenko, A. (2024). Economic, institutional and environmental drivers of SMEs' development in the EU: Sustainable development goals perspective. Environment, Development and Sustainability, 27(8): 20101-20119. https://doi.org/10.1007/s10668-024-05686-z

[6] Azemi, F., Šimunović, G., Lujić, R., Tokody, D., Mulaku, L. (2023). Green manufacturing and environmental sustainability manufacturing in Kosovo's small and middle enterprises, barriers to implementation. Tehnicki vjesnik - Technical Gazette, 30(3): 988-992. https://doi.org/10.17559/TV-20220528121801

[7] Durrani, N., Raziq, A., Mahmood, T., Khan, M.R. (2024). Barriers to adaptation of environmental sustainability in SMEs: A qualitative study. PLoS ONE, 19(5): e0298580. https://doi.org/10.1371/journal.pone.0298580

[8] Musaad O, A.S., Zhuo, Z., Musaad O, A.O., Ali Siyal, Z., Hashmi, H., Shah, S.A.A. (2020). A fuzzy multi-criteria analysis of barriers and policy strategies for small and medium enterprises to adopt green innovation. Symmetry, 12(1): 116. https://doi.org/10.3390/SYM12010116

[9] Singh, M.P., Chakraborty, A., Roy, M., Tripathi, A. (2020). Developing SME sustainability disclosure index for Bombay Stock Exchange (BSE) listed manufacturing SMEs in India. Environment, Development and Sustainability, 23(1): 399-422. https://doi.org/10.1007/s10668-019-00586-z

[10] Elhusseiny, H.M., Crispim, J. (2022). SMEs, barriers and opportunities on adopting Industry 4.0: A review. Procedia Computer Science, 196: 864-871. https://doi.org/10.1016/j.procs.2021.12.086

[11] Kumar, D., Ghosh, S.K. (2026). The role of small and medium enterprises (SMEs) in achieve sustainable development goals (SDGs) in Bangladesh. In Vulnerability and the Future of Small Business in Industry 5.0, pp. 23-48. https://doi.org/10.1007/978-3-031-98431-0_2

[12] Gupta, H., Mondal, S., Singh, S., Kharub, M. (2023). Industry 4.0 and green entrepreneurship for environmental sustainability: Exploring barriers from an Indian SME perspective. In Lecture notes in Operations Research, pp. 77-108. https://doi.org/10.1007/978-3-031-40328-6_6

[13] Narwane, V.S., Raut, R.D., Gardas, B.B., Narkhede, B.E., Awasthi, A. (2022). Examining smart manufacturing challenges in the context of micro, small and medium enterprises. International Journal of Computer Integrated Manufacturing, 35(12): 1395-1412. https://doi.org/10.1080/0951192X.2022.2078508

[14] Alayón, C.L., Säfsten, K., Johansson, G. (2022). Barriers and enablers for the adoption of sustainable manufacturing by manufacturing SMEs. Sustainability, 14(4): 2364. https://doi.org/10.3390/su14042364

[15] Madrid-Guijarro, A., Duréndez, A. (2023). Sustainable development barriers and pressures in SMEs: The mediating effect of management commitment to environmental practices. Business Strategy and the Environment, 33(2): 949-967. https://doi.org/10.1002/bse.3537

[16] Neri, A., Cagno, E., Trianni, A. (2021). Barriers and drivers for the adoption of industrial sustainability measures in European SMEs: Empirical evidence from chemical and metalworking sectors. Sustainable Production and Consumption, 28: 1433-1464. https://doi.org/10.1016/j.spc.2021.08.018

[17] Tanco, M., Kalemkerian, F., Santos, J. (2021). Main challenges involved in the adoption of sustainable manufacturing in Uruguayan small and medium sized companies. Journal of Cleaner Production, 293: 126139. https://doi.org/10.1016/j.jclepro.2021.126139

[18] Iqbal, U.P., Nooney, L.K., Al Ghafri, F.S.S., Daniel, T.M. (2025). Sustainable business practices in SMEs: A retrospective insight on catalysts and hurdles. Cogent Business & Management, 12(1). https://doi.org/10.1080/23311975.2025.2456114

[19] Mahmud, P., Paul, S.K., Azeem, A., Chowdhury, P. (2021). Evaluating supply chain collaboration barriers in small- and medium-sized enterprises. Sustainability, 13(13): 7449. https://doi.org/10.3390/su13137449

[20] O'Leary, S., Lieberman, S., Gulyas, A., Ogilvie, M., Bates, D., Heath, T., Pelz, C., Williams, S., Shalet, D. (2023). Management actions to address the climate emergency: Motivations and barriers for SMEs and other societal micro/meso-level groups. The International Journal of Management Education, 21(3): 100831. https://doi.org/10.1016/j.ijme.2023.100831

[21] Olipp, N., Woschank, M., Kopeinig, J. (2024). Enablers, barriers, and opportunities for the implementation of circular economy practices in small and medium-sized enterprises: An explorative systematic literature review. In the 3rd International Symposium on Industrial Engineering and Automation, Bolzano, Italy, pp. 185-199. https://doi.org/10.1007/978-3-031-70465-9_19

[22] Costache, C., Dumitrascu, D.D., Maniu, I. (2021). Facilitators of and barriers to sustainable development in small and medium-sized enterprises: A descriptive exploratory study in Romania. Sustainability, 13(6): 3213. https://doi.org/10.3390/su13063213

[23] Dugolli, M. (2021). Occupational, health and safety situation at small and medium enterprises in Kosovo, contextual factors, barriers, drivers and intervention process. International Review of Applied Sciences and Engineering, 12(1): 19-28. https://doi.org/10.1556/1848.2020.00110

[24] Gonçalves, H., Magalhães, V.S.M., Ferreira, L.M.D.F., Arantes, A. (2024). Overcoming barriers to sustainable supply chain management in small and medium-sized

enterprises: A multi-criteria decision-making approach. Sustainability, 16(2): 506. https://doi.org/10.3390/su16020506

[25] Moursellas, A., De, D., Wurzer, T., Skouloudis, A., Reiner, G., Chaudhuri, A., Manousidis, T., Malesios, C., Evangelinos, K., Dey, P.K. (2022). Sustainability practices and performance in European small-and-medium enterprises: Insights from multiple case studies. Circular Economy and Sustainability, 3(2): 835-860. https://doi.org/10.1007/s43615-022-00224-3

[26] Singh, S.K., Mohanty, A.M. (2020). Issues with Indian SMEs: A sustainability-oriented approach for finding potential barriers. In Innovative Product Design and Intelligent Manufacturing Systems, pp. 159-166. https://doi.org/10.1007/978-981-15-2696-1_15

[27] Steidle, C., Ostojic, S., Achterfeldt, S., Traverso, M. (2025). Small players, big impact? Unveiling practices and challenges of sustainability reporting by German SMEs. Discover Sustainability, 6(1): 780. https://doi.org/10.1007/s43621-025-01727-3

[28] Ali, M., Ahmed, F. (2024). Toward sustainable ERP systems and their impact on individual performance in manufacturing SMEs: Evidence from a North African developing country. International Journal of Emerging Markets, 21(1): 1-24. https://doi.org/10.1108/IJOEM-06-2024-1102

[29] Mishra, A.R., Rani, P., Pamucar, D., Simic, V. (2024). Evaluation and prioritization of sustainable enterprise resource planning in SMEs using q-rung orthopair fuzzy rough set-based decision support model. IEEE Transactions on Fuzzy Systems, 32(5): 3260-3273. https://doi.org/10.1109/TFUZZ.2024.3374799

[30] Nurdin, C., Yanuar Ridwan, A., Septo Hediyanto, U.Y.K. (2023). Applying the circular economy concept in sales management dashboard at MSMEs using ERP systems. In 2023 3rd International Conference on Electronic and Electrical Engineering and Intelligent System (ICE3IS), Yogyakarta, Indonesia, pp. 371-376. https://doi.org/10.1109/ICE3IS59323.2023.10335334

[31] Bag, S., Wood, L.C., Xu, L., Dhamija, P., Kayikci, Y. (2020). Big data analytics as an operational excellence approach to enhance sustainable supply chain performance. Resources, Conservation and Recycling, 153: 104559. https://doi.org/10.1016/j.resconrec.2019.104559

[32] Belhadi, A., Kamble, S.S., Zkik, K., Cherrafi, A., Touriki, F.E. (2020). The integrated effect of big data analytics, lean six sigma and green manufacturing on the environmental performance of manufacturing companies: The case of North Africa. Journal of Cleaner Production, 252: 119903. https://doi.org/10.1016/j.jclepro.2019.119903

[33] Benzidia, S., Makaoui, N., Bentahar, O. (2021). The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance. Technological Forecasting and Social Change, 165: 120557. https://doi.org/10.1016/j.techfore.2020.120557

[34] Basu, A., Dutta, S., Ghosh, S. (2022). Exploring appropriate ERP framework towards Indian small and medium enterprises using decision tree. International Journal of Business Intelligence and Data Mining, 21(4): 510. https://doi.org/10.1504/ijbidm.2022.126502

[35] Razzaq, A. (2021). Propose a conceptual framework for the cloud ERP adoption among Malaysian SMEs. Journal of Engineering Science and Technology, 16(4): 3387-3406.

[36] Kulkov, I., Kulkova, J., Rohrbeck, R., Menvielle, L., Kaartemo, V., Makkonen, H. (2023). Artificial intelligence driven sustainable development: Examining organizational, technical, and processing approaches to achieving global goals. Sustainable Development, 32(3): 2253-2267. https://doi.org/10.1002/sd.2773

[37] Denicolai, S., Zucchella, A., Magnani, G. (2021). Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths. Technological Forecasting and Social Change, 166: 120650. https://doi.org/10.1016/j.techfore.2021.120650

[38] Dora, M., Kumar, A., Mangla, S.K., Pant, A., Kamal, M.M. (2021). Critical success factors influencing artificial intelligence adoption in food supply chains. International Journal of Production Research, 60(14): 4621-4640. https://doi.org/10.1080/00207543.2021.1959665

[39] Trist, E.L. (1981). The evolution of Socio-Technical Systems. Toronto: Ontario Quality of Working Life Centre.

[40] Sony, M., Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. Technology in Society, 61: 101248. https://doi.org/10.1016/j.techsoc.2020.101248

[41] Appelbaum, S.H. (1997). Sociotechnical systems theory: An intervention strategy for organizational development. Management Decision, 35(6): 452-463. https://doi.org/10.1108/00251749710173823

[42] Junejo, I., Sohu, J.M., Qureshi, A.A., Shaikh, S., Ejaz, F., Jagirani, T.S., Hossain, M.B. (2025). The green supply chain conundrum: Exploring the interplay of practices, performance, and technology in shaping SME sustainability in developing country. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-025-06614-5

[43] Pandey, V., Kumar, S., Gupta, S., Khatri, N. (2024). Unlocking sustainability: Prioritizing barriers for SME success in India with AHP analysis. Journal of Global Entrepreneurship Research, 14(1): 25. https://doi.org/10.1007/s40497-024-00395-3

[44] Jamwal, A., Agrawal, R., Sharma, M. (2023). Challenges and opportunities for manufacturing SMEs in adopting Industry 4.0 technologies for achieving sustainability: Empirical evidence from an emerging economy. Operations Management Research, 18(2): 718-743. https://doi.org/10.1007/s12063-023-00428-2

[45] Zaman, M., Tanewski, G., Ekanayake, G. (2025). What does sustainability mean for small and medium enterprises: A systematic literature review. Journal of Cleaner Production, 492: 144830. https://doi.org/10.1016/j.jclepro.2025.144830

[46] Putri, A.N.A., Hermawan, P., Mirzanti, I.R., Meadows, M., Sadraei, R. (2025). Unpacking green growth in SMEs: A framework for dynamic capabilities, value co-creation, and sustainable performance. Sustainable Futures, 10: 100840. https://doi.org/10.1016/j.sftr.2025.100840

[47] Trist, E., Pasmore, W.A., Sherwood, J.J. (1960). Socio-Technical Systems. London: Tavistock.

[48] Viswanathan, R., Telukdarie, A. (2021). A systems

dynamics approach to SME digitalization. Procedia Computer Science, 180: 816-824. https://doi.org/10.1016/j.procs.2021.01.331
[49] AlZayani, F., Hamdan, A., Shoaib, H.M. (2023). The impact of smart technologies on SME sustainability: The mediation effect of sustainability strategy – Literature review. In Technological Sustainability and Business Competitive Advantage, pp. 431-454. https://doi.org/10.1007/978-3-031-35525-7_27
[50] Haq, F.U., Suki, N.M., Setini, M., Masood, A., Khan, T.A. (2025). Adopting green AI for SME sustainability: Mediating role of green investment and moderation by green servant leadership. Sustainable Futures, 10: 101002. https://doi.org/10.1016/j.sftr.2025.101002
[51] Sivaganthan, S.P., Mukred, M., Mohammed, F., Leen, M.W.E. (2025). A study on the use of enterprise resource planning to improve the sustainability of Malaysian SMEs. In Current and Future Trends on AI Applications, pp. 395-409. https://doi.org/10.1007/978-3-031-75091-5_21
[52] Zheng, J., Khalid, H. (2022). The adoption of enterprise resource planning and business intelligence systems in small and medium enterprises: A conceptual framework. Mathematical Problems in Engineering, 2022: 1-15. https://doi.org/10.1155/2022/1829347
[53] Lacurezeanu, R., Chis, A., Bresfelean, V.P. (2021). Integrated management solution for a sustainable SME—Selection proposal using AHP. Sustainability, 13(19): 10616. https://doi.org/10.3390/su131910616
[54] Siregar, T., Puspitasari, W., Saputra, M. (2022). ERP in Indonesia SMEs: A study for post implementation evaluation from user's perspective acceptance. In 2022 International Conference on ICT for Smart Society (ICISS), Bandung, Indonesia, pp. 1-6. https://doi.org/10.1109/ICISS55894.2022.9915088
[55] Sarwono, R., Gunawan, A.B., Risdianovi, N. (2025). Enterprise resource planning-based managerial inventory management for SMEs industry. In 2025 International Conference on Informatics, Multimedia, Cyber and Information System (ICIMCIS), Jakarta, Indonesia, pp. 497-501. https://doi.org/10.1109/ICIMCIS68501.2025.11327397
[56] Llivisaca-Villazhañay, J., Flores-Siguenza, P., Guamán, R., Urdiales, C., Gento-Municio, Á.M. (2025). Key drivers of ERP implementation in digital transformation: Evidence from Austro-Ecuadorian. Administrative Sciences, 15(6): 196. https://doi.org/10.3390/admsci15060196
[57] Meiryani, Sylvania, S., Yunita. (2023). Assessing accountant's satisfaction through accounting benefits and technology acceptance model (TAM) in ERP system implementation: A quantitative study on SMEs in Indonesia. In 2023 International Conference on Innovation, Knowledge, and Management (ICIKM), Portsmouth, United Kingdom, pp. 31-37. https://doi.org/10.1109/ICIKM59709.2023.00015
[58] Kar, A.K., Choudhary, S.K., Singh, V.K. (2022). How can artificial intelligence impact sustainability: A systematic literature review. Journal of Cleaner Production, 376: 134120. https://doi.org/10.1016/j.jclepro.2022.134120
[59] Chen, C., Hu, Y., Karuppiah, M., Kumar, P.M. (2021). Artificial intelligence on economic evaluation of energy efficiency and renewable energy technologies. Sustainable Energy Technologies and Assessments, 47: 101358. https://doi.org/10.1016/j.seta.2021.101358
[60] Magazzino, C., Mele, M., Schneider, N. (2021). A machine learning approach on the relationship among solar and wind energy production, coal consumption, GDP, and CO2 emissions. Renewable Energy, 167: 99-115. https://doi.org/10.1016/j.renene.2020.11.050
[61] Pham, A.D., Ngo, N.T., Ha Truong, T.T., Huynh, N.T., Truong, N.S. (2020). Predicting energy consumption in multiple buildings using machine learning for improving energy efficiency and sustainability. Journal of Cleaner Production, 260: 121082. https://doi.org/10.1016/j.jclepro.2020.121082
[62] Liu, L., Song, W., Liu, Y. (2023). Leveraging digital capabilities toward a circular economy: Reinforcing sustainable supply chain management with Industry 4.0 technologies. Computers & Industrial Engineering, 178: 109113. https://doi.org/10.1016/j.cie.2023.109113
[63] Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S.D., Tegmark, M., Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications, 11(1): 233. https://doi.org/10.1038/s41467-019-14108-y
[64] Sjödin, D., Parida, V., Kohtamäki, M. (2023). Artificial intelligence enabling circular business model innovation in digital servitization: Conceptualizing dynamic capabilities, AI capacities, business models and effects. Technological Forecasting and Social Change, 197: 122903. https://doi.org/10.1016/j.techfore.2023.122903
[65] Nishant, R., Kennedy, M., Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. International Journal of Information Management, 53: 102104. https://doi.org/10.1016/j.ijinfomgt.2020.102104
[66] Kristoffersen, E., Mikalef, P., Blomsma, F., Li, J. (2021). The effects of business analytics capability on circular economy implementation, resource orchestration capability, and firm performance. International Journal of Production Economics, 239: 108205. https://doi.org/10.1016/j.ijpe.2021.108205
[67] Di Vaio, A., Boccia, F., Landriani, L., Palladino, R. (2020). Artificial intelligence in the agri-food system: Rethinking sustainable business models in the COVID-19 scenario. Sustainability, 12(12): 4851. https://doi.org/10.3390/SU12124851
[68] Mhlanga, D. (2021). Artificial intelligence in the industry 4.0, and its impact on poverty, innovation, infrastructure development, and the Sustainable Development Goals: Lessons from emerging economies? Sustainability, 13(11): 5788. https://doi.org/10.3390/su13115788
[69] Kamble, S.S., Gunasekaran, A., Parekh, H., Mani, V., Belhadi, A., Sharma, R. (2022). Digital twin for sustainable manufacturing supply chains: Current trends, future perspectives, and an implementation framework. Technological Forecasting and Social Change, 176: 121448. https://doi.org/10.1016/j.techfore.2021.121448
[70] Murnawan, H., Purnomo, H. (2026). Optimization of sustainable dairy production processes: A system dynamics approach. Process Integration and Optimization for Sustainability. https://doi.org/10.1007/s41660-026-00732-x
[71] Nurwildani, M.F., Purnomo, H., Soewardi, H., Kusrini, E. (2025). Ergonomic study in developing the

organizational culture to improve SME's performance. Journal of Applied Engineering and Technological Science (JAETS), 7(1): 483-498. https://doi.org/10.37385/jaets.v7i1.8084
[72] Khan, S., Faisal, S. (2023). Green human resource management and organizational sustainability: A systematic literature review and bibliometric analysis. International Journal of Sustainable Development and Planning, 18(4): 1255-1262. https://doi.org/10.18280/ijsdp.180430
[73] Hidayatullah, A.A., Purnomo, H., Soewardi, H., Widodo, I.D. (2025). Conceptual framework for sustainability in chili processing MSMEs. AIP Conference Proceedings, 3351: 030001. https://doi.org/10.1063/5.0303391
[74] Sabauri, L. (2025). Challenges in preparing sustainable reporting for SMEs in Georgia: A comparative analysis with Armenia and Azerbaijan. International Journal of Sustainable Development and Planning, 20(9): 4081-4089. https://doi.org/10.18280/ijsdp.200937
[75] Strohm, L., Hehakaya, C., Ranschaert, E.R., Boon, W.P.C., Moors, E.H.M. (2020). Implementation of artificial intelligence (AI) applications in radiology: Hindering and facilitating factors. European Radiology, 30(10): 5525-5532. https://doi.org/10.1007/s00330-020-06946-y

NOMENCLATURE

Symbol	
AI	Artificial Intelligence
DSS	Decision Support System
ERP	Enterprise Resource Planning
GHRM	Green Human Resource Management
IQR	Interquartile Range
MCDM	Multi-Criteria Decision Making
MSME	Micro, Small, and Medium-sized Enterprise
SDGs	Sustainable Development Goals
SME	Small and Medium-sized Enterprise
SSCM	Sustainable Supply Chain Management
STS	Socio-Technical Systems

APPENDIX

Table A1 presents the complete list of 52 core articles included in the systematic literature review, detailing their thematic classification, focus areas, and analytical roles to ensure transparency and reproducibility of the study.

Table A1. Complete list of 52 core articles

No.	Author(s)	Year	Theme	Focus Area	Analytical Role
1	Musaad, A.	2020	Barriers	Sustainability barriers in SMEs	Failure mechanism
2	Alayón, C.	2022	Barriers	Sustainable manufacturing barriers	Organisational constraint
3	Neri, A.	2021	Barriers	Sustainability implementation barriers	Capability limitation
4	Durrani, A.	2024	Barriers	Environmental sustainability barriers	Financial constraint
5	Kumar, R.	2023	Barriers	Industry 4.0 sustainability barriers	Technological constraint
6	Costache, C.	2021	Barriers	Sustainability barriers and drivers	Market constraint
7	Tanco, M.	2021	Barriers	Adoption challenges in SMEs	Operational constraint
8	Madrid-Guijarro, A.	2024	Barriers	Sustainability strategy barriers	Managerial limitation
9	Moursellas, C.	2024	Barriers	Sustainability transition barriers	Institutional constraint
10	Gonçalves, R.	2024	Barriers	Supply chain sustainability barriers	External constraint
11	Mahmud, M.	2021	Barriers	CSR barriers in SMEs	Knowledge limitation
12	Singh, R.	2022	Barriers	Sustainability integration barriers	Strategic constraint
13	Olipp, F.	2024	Barriers	Market-related sustainability barriers	Demand constraint
14	Narwane, V.	2022	Barriers	Technological barriers in SMEs	Digital limitation
15	Azemi, Y.	2023	Barriers	Financial barriers in sustainability	Investment limitation
16	Gupta, S.	2023	Barriers	Data and system limitations	Information constraint
17	O'Leary, D.	2023	Barriers	Sustainability decision barriers	Managerial constraint
18	Dugolli, M.	2021	Barriers	Process-related barriers	Operational limitation
19	Elhusseiny, H.	2021	Barriers	Knowledge barriers	Learning limitation
20	Iqbal, M.	2025	Barriers	Capability barriers	Skill limitation
21	Sivaganthan, S.P.	2025	ERP	ERP for SME sustainability	Integration mechanism
22	Nurdin, C.	2023	ERP	ERP and circular economy	Sustainability enabler
23	Meiryani	2023	ERP	ERP implementation	Adoption mechanism
24	Mishra, A.R.	2024	ERP	Sustainable ERP systems	Decision framework
25	Ali, M.	2026	ERP	ERP impact on performance	Outcome driver
26	Basu, A.	2024	ERP	ERP adoption in SMEs	Capability driver
27	Siregar, T.	2022	ERP	ERP post-implementation	Performance gap
28	Sarwono, R.	2025	ERP	ERP-based operations	Operational control
29	Llivisaca-Villazhañay, J.	2025	ERP	ERP drivers	Transformation enabler
30	Zheng, J.	2022	ERP	ERP and BI	Data integration
31	Razzaq, A.	2021	ERP	Cloud ERP	Technology access
32	Lacurezeanu, R.	2021	ERP	Integrated systems	System integration
33	Benzidia, S.	2021	AI	AI in supply chain	Optimization
34	Belhadi, A.	2020	AI	AI in manufacturing	Efficiency improvement
35	Bag, S.	2021	AI	AI and circular economy	Sustainability driver
36	Liu, Y.	2023	AI	Digital capability	Process optimisation
37	Kristoffersen, E.	2021	AI	Analytics capability	Circular economy
38	Sjödin, D.	2023	AI	AI and business model	Innovation driver
39	Vaio, A.	2020	AI	AI sustainability strategy	Strategic enabler
40	Kulkov, I.	2024	AI	AI transformation	Adaptive capability

41	Nishant, R.	2020	AI	AI for sustainability	Theoretical foundation
42	Kar, A.K.	2022	AI	AI systematic review	Conceptual mapping
43	Vinuesa, R.	2020	AI	AI and SDGs	Sustainability framework
44	Goralski, M.	2020	AI	AI and development	Impact analysis
45	Strohm, M.	2020	AI	AI adoption barriers	Constraint analysis
46	Dora, M.	2022	AI	AI adoption in SMEs	Success factors
47	Mhlanga, D.	2021	AI	AI and SDGs	Emerging economy insight
48	Pham, Q.	2020	AI	AI in energy	Efficiency
49	Magazzino, C.	2021	AI	AI and energy	Sustainability impact
50	Chen, X.	2021	AI	AI and environment	Environmental optimisation
51	Kamble, S.	2020	AI	Industry 4.0 SMEs	Readiness
52	Denicolai, S.	2021	AI	Digital readiness SMEs	Capability