Drivers and Obstacles: A Narrative Review of Green Technology Adoption in SMEs

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DOI: https://doi.org/10.47772/IJRISS.2025.91100538

Received: 09 December 2025; Accepted: 16 December 2025; Published: 23 December 2025

ABSTRACT

Small and medium-sized enterprises (SMEs) are pivotal to economic development yet major contributors to industrial pollution, underscoring the need for their adoption of green technologies for sustainable transitions. This narrative review synthesizes findings from 122 studies (2009–2025) to map the complex landscape of obstacles and enablers influencing green technology adoption in SMEs globally. Drawing on institutional theory, resource-based, and diffusion-of-innovation perspectives, the analysis, spanning diverse geographic regions (Europe, Asia, emerging economies) and sectors (manufacturing, services), identifies financial constraints (high initial costs, limited capital access) as the most pervasive barrier, especially in developing economies. Additional challenges include knowledge gaps, regulatory complexities, and organizational inertia. Conversely, strong internal drivers (managerial commitment, environmental values) coupled with external support (government incentives, collaborative networks, market pressures) significantly promote adoption. The review highlights the dynamic interplay and contextual dependence of these factors, underscoring how targeted policy and strategic management can overcome barriers. Emerging trends, such as digitalization and circular economy principles, present new pathways for SME engagement. By integrating these insights, the review proposes a testable conceptual framework that delineates the direct, moderating, and interactive roles of key factors, providing a structured foundation for future research, policy design, and managerial practice aimed at accelerating the uptake of green technologies in the vital SME sector.

Keywords: Green technology adoption, Small and medium-sized enterprises (SMEs), Barriers, Enablers, Sustainable development

INTRODUCTION

SMEs constitute approximately 90% of businesses worldwide and are vital to economic growth, innovation, and job creation (Klewitz et al., 2012). Despite their numbers, SMEs collectively account for up to 70% of global industrial pollution, posing a significant environmental challenge that requires urgent action (Mitchell et al., 2020). The shift toward sustainable development models puts SMEs at a critical point, where adopting green technologies and eco-innovations is essential not only for environmental responsibility but also for long-term competitiveness and resilience.

Green technology adoption in SMEs encompasses practices such as energy-saving processes, waste-reduction systems, circular-economy initiatives, and sustainable product innovations (Bag et al., 2022; Triguero et al., 2015). However, the path toward sustainability presents unique challenges for SMEs compared to larger companies. Their smaller size, limited resources, and reduced capabilities lead to specific adoption patterns that need specialized understanding and targeted support strategies.

Although extensive research has examined green technology adoption in various contexts, the SME sector remains relatively underexplored despite its economic and environmental importance. The existing literature is scattered across regions, industries, and technologies, and lacks a comprehensive overview of the main factors that influence adoption decisions. This review addresses this gap by systematically analyzing 122 studies

published between 2009 and 2025 to develop an integrated understanding of the barriers and enablers impacting green technology adoption in SMEs.

The main research questions guiding this review are:

1. What are the main obstacles preventing SMEs from adopting green technologies?

2. What factors motivate and support SMEs in overcoming these barriers?

3. How do these factors affect different contexts and types of innovation?

4. What are the emerging trends and research gaps in this field?

By examining these questions, this review offers valuable insights for SME managers, policymakers, researchers, and other stakeholders interested in promoting sustainable business practices among small and medium enterprises.

METHODOLOGY

Search Strategy and Selection Criteria

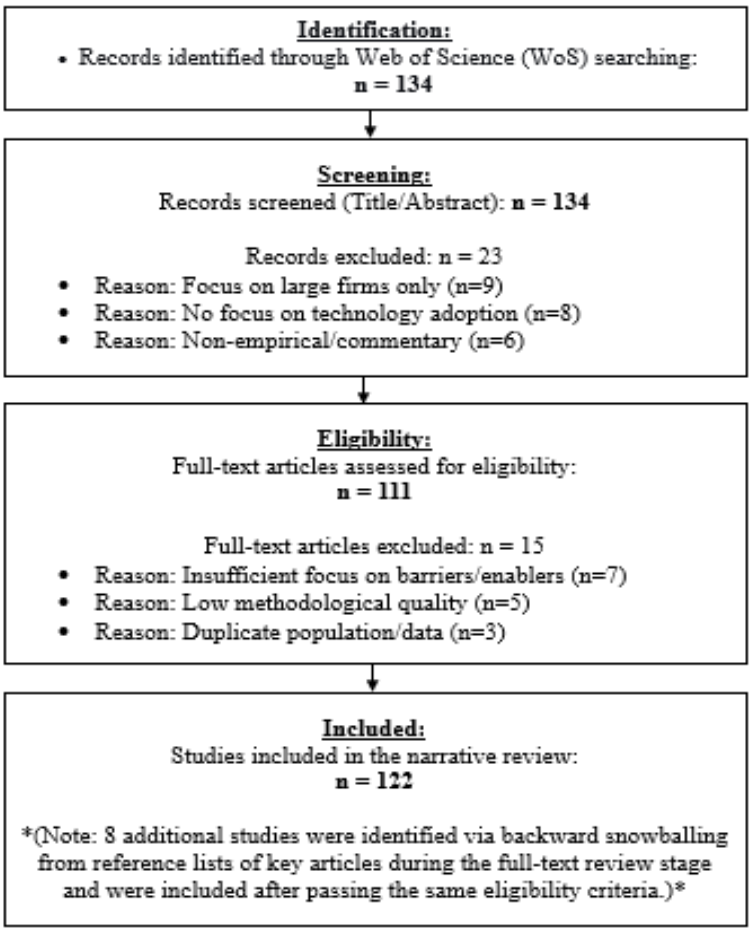
This narrative review employed a systematic search strategy across the Web of Science (WoS) Core Collection to identify relevant literature. The search query combined key terms related to green technologies ("green technology," "sustainable technology," "eco-innovation"), adoption processes ("adoption," "uptake," "implementation"), organizational context ("small and medium enterprises," "SME," "MSME"), and influencing factors ("barriers," "obstacles," "challenges," "enablers," "drivers," "motivators"). The search was limited to English-language articles published from January 2009 to March 2025 to capture both foundational and contemporary perspectives. The articles were retrieved on November 27, 2025.

The initial search yielded 134 articles. A two-step screening process was then applied. First, titles and abstracts were reviewed for relevance to the core research questions. Articles were excluded if they focused exclusively on large corporations, discussed environmental issues without a clear technological adoption component, or were non-empirical (e.g., purely theoretical commentaries). Second, the full text of the remaining articles was evaluated for methodological quality, empirical contribution, and direct relevance to understanding adoption factors in SMEs. This rigorous screening process resulted in 122 articles forming the final review corpus. To enhance transparency, a flow diagram detailing the identification, screening, eligibility, and inclusion processes is shown in Figure 1.

Quality Assessment and Inclusion Rationale

To ensure the reliability and relevance of the included studies, a formal quality assessment was conducted for each article that passed the initial screening. Studies were evaluated based on the following criteria: (1) clarity of research objectives and alignment with the review's focus, (2) rigor of methodological design and appropriateness of data analysis, (3) transparency in reporting findings, and (4) significance of contributions to understanding adoption factors in SMEs. Articles that scored low across multiple criteria were excluded to maintain the review's analytical integrity. The decision to confine the search to the WoS Core Collection was strategic, as WoS is a premier multidisciplinary database renowned for its rigorous journal indexing and consistent quality standards, ensuring the inclusion of high-impact, peer-reviewed literature. While acknowledging that this approach may exclude relevant grey literature, the focus on WoS was chosen to prioritize scholarly depth and methodological credibility, which are central to a narrative synthesis aimed at mapping established academic knowledge.

Figure 1: Flow diagram of the study selection process



This diagram outlines the systematic process used to identify, screen, and include relevant studies for this narrative review, from the initial database search to the final corpus of 122 articles.

Analytical Approach

The analytical approach followed established narrative review methods, emphasizing thematic synthesis and interpretation rather than statistical meta-analysis. Each of the 122 included articles was systematically coded using a standardized template to extract details on: research context (geographical region, industry sector), methodological design (qualitative, quantitative, mixed-methods), theoretical framework, and key empirical findings related to barriers and enablers. Common patterns and divergent insights were identified through iterative, comparative analysis across studies. This process facilitated the inductive development of the thematic categories (e.g., Financial Constraints, Internal Drivers) that structure the presentation of findings in this review. The analysis of theoretical frameworks across the sampled literature is synthesized in a dedicated section ('The Underpinning Theories') following this methodology.

Limitations of the Narrative Review Approach

While this narrative synthesis provides a comprehensive and nuanced understanding of the literature, it is important to acknowledge its inherent limitations. As a qualitative synthesis, it does not involve statistical aggregation of effect sizes (meta-analysis), which limits the ability to quantify the relative strength of different barriers or enablers. Furthermore, despite employing a systematic search, the selection and interpretation of studies are subject to potential researcher bias. The focus on peer-reviewed journal articles in the WoS may also exclude relevant insights from grey literature or publications in other databases. These limitations are counterbalanced by the depth of contextual and thematic analysis that a narrative review affords, which is particularly well suited to exploring complex, multifaceted phenomena such as technology adoption.

Profile of the Included Literature

The 122 studies encompass a wide range of geographic and sectoral contexts, providing a broad evidence base. Geographically, the largest share of studies originates from European countries (38%) and Asian economies (32%), with a further 18% from emerging markets in Africa and Latin America; the remaining 12% are multi-regional or from other regions. In terms of sectoral focus, manufacturing industries are the most studied (45%), followed by services (25%), agriculture (15%), and cross-sectoral studies (15%). Methodologically, quantitative approaches (e.g., surveys, econometric analysis) are the most common (55%), followed by qualitative case studies (35%) and mixed-methods designs (10%), reflecting the field's growing empirical maturity.

Visual Representation and Referencing

To enhance transparency and clarity, key processes and conceptual relationships are presented visually. Figure 1 depicts the flow diagram, detailing the study selection process from identification to inclusion. This figure provides a transparent account of the screening and eligibility stages applied to the 134 records initially identified.

Furthermore, the integrative conceptual model developed from the thematic synthesis is presented in Figure 2. This figure illustrates the proposed framework, positioning Green Technology Adoption Decision & Process as the central outcome influenced by barriers and enablers, moderated by contextual layers, and characterized by dynamic interactions and feedback loops. For a detailed breakdown of the constructs, their definitions, and the hypothesized relationships underpinning Figure 2, please refer to Table 2.

LITERATURE REVIEW

The Underpinning Theories

The literature on green technology adoption in SMEs is informed by several complementary theoretical lenses, which collectively help explain the multifaceted barriers and enablers identified in this review. While individual studies vary in their explicit theoretical grounding, three dominant perspectives emerge as particularly salient: institutional theory, the resource-based view (RBV), and the diffusion of innovations (DOI) theory. An integration of these frameworks conceptually underpins this review’s thematic synthesis.

Institutional Theory provides a macro-level lens, explaining how external pressures and norms shape organizational behavior. It highlights the role of coercive pressures from government regulations, mimetic pressures from competitors, and normative pressures from industry associations or professional networks in driving (or hindering) adoption (DiMaggio & Powell, 1983). This theory is crucial for understanding the enablers and barriers categorized as regulatory, market-based, and collaborative. For instance, it helps explain why inconsistent regulations (weak coercive pressure) or the absence of industry norms can act as significant barriers. In contrast, strong policy incentives and collaborative networks can serve as powerful enablers.

RBV offers an internal, firm-level perspective, positing that sustainable competitive advantage stems from a firm’s unique bundle of valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities (Barney, 1991). In the context of green adoption, the RBV focuses on the internal drivers and constraints central to this review. Financial capital, technical knowledge, managerial commitment, and organizational culture are analyzed as key strategic resources. The pervasive barrier of "resource limitations" and the enabling role of "internal capabilities" are directly interpretable through an RBV lens, which frames adoption as a strategic investment contingent on the firm’s resource endowment and absorptive capacity.

DOI Theory bridges the internal and external by focusing on the characteristics of the innovation itself and the communication channels through which it spreads (Rogers, 2003). It examines how perceptions of an innovation’s relative advantage, compatibility, complexity, trialability, and observability influence its adoption rate. This theory is instrumental in understanding the "knowledge and capability" barriers, as complexity and incompatibility with existing processes can slow uptake. Conversely, demonstration projects (enhancing

trialability and observability) and clear communication of economic benefits (relative advantage) are key enablers explained by DOI.

By drawing on these interconnected theories, this review moves beyond a simple listing of factors. It enables a more nuanced interpretation of how external institutional forces (Institutional Theory) interact with internal resource decisions (RBV) and are mediated by the perceived attributes of green technologies (DOI), shaping the adoption landscape for SMEs. This integrated theoretical foundation informs the subsequent thematic analysis and provides the building blocks for the overarching conceptual framework developed in the final synthesis (see Figure 2 and Table 2).

The Multifaceted Barriers To Green Adoption In SMEs

Financial and Economic Constraints

Financial constraints are the most pervasive barrier to the adoption of green technologies in SMEs, particularly in emerging economies. The primary challenges include high upfront investment costs and limited access to capital or credit, compounded by perceived high risk and uncertain returns, which deter banks and investors (Fahad et al., 2022; Rybarova et al., 2023). The nature of the constraint varies by context: in developed economies, competition for investment capital and cost-benefit uncertainties dominate (Demirel & Danisman, 2019), whereas in emerging economies, fundamental issues of capital access and high borrowing costs are more acute (Austin et al., 2025). Ongoing costs, such as maintenance, operational disruption, and opportunity costs, further divert attention from green investments, especially when immediate business survival is prioritized (Gupta & Barua, 2018).

Knowledge, Capability, and Resource Limitations

SMEs frequently lack the internal capabilities required to identify, evaluate, and implement green technologies effectively. Central knowledge gaps include limited technical understanding of available solutions, low awareness of environmental regulations and support programs, and deficient internal R&D capacity, collectively creating significant information asymmetries in the market (Ansari & Kant, 2021; Chibelushi & Costello, 2009). These gaps are exacerbated by human resource constraints, as SMEs typically have fewer specialized staff to manage environmental issues or conduct technology assessments, often relegating sustainability to a secondary role for overburdened employees (Shahin et al., 2024). The general absence of formal R&D functions further restricts experimentation with uncertain technologies, fostering technological dependency and reinforcing a conservative, risk-averse approach to adoption (Saez-Martinez et al., 2016).

Regulatory, Institutional, and Market Barriers

Navigating complex, unstable, or poorly enforced environmental regulations imposes a significant burden on SMEs, which often lack the legal and administrative resources to comply (Garcia-Quevedo et al., 2020). This challenge is compounded in contexts with institutional weaknesses, where corruption or lack of transparency can distort incentives, as illustrated by findings that bribery can positively influence environmental innovation decisions in some settings (Ha et al., 2021). Concurrently, market conditions often discourage investment; uncertain consumer demand for green products, high price sensitivity, and competition based primarily on traditional cost factors rather than environmental performance reduce the perceived immediate payoff of green technologies (Marin et al., 2015).

Organizational and Managerial Challenges

Internal organizational factors present substantial barriers. Leadership commitment is pivotal; however, many SME owners and managers perceive environmental issues as secondary to core financial and operational objectives, particularly when they lack personal environmental knowledge or technical expertise (Fernandez-Muniz et al., 2024). This is often reinforced by a conservative organizational culture resistant to change, epitomized by an "if it is not broken, do not fix it" mentality, which is prevalent in firms with limited capacity to manage disruption (Isensee et al., 2020). Furthermore, while typical SME structures are agile, they often lack

formal processes for strategic technology evaluation and long-term sustainability planning, thereby forcing a focus on short-term operational concerns (Mitchell et al., 2020).

Key Enablers Driving Green Adoption

Internal Drivers: Leadership, Capabilities and Organizational Ethos

Strong internal drivers are critical for overcoming external barriers. Managerial environmental commitment and values consistently emerge as a foundational enabler, shaping organizational priorities and resource allocation when leaders view sustainability as a strategic or ethical imperative (Han & Chen, 2021; Hojnik & Ruzzier, 2016). Developing internal capabilities, particularly absorptive capacity, the ability to assimilate and apply external knowledge, is equally vital and can be strengthened through investments in employee training and organizational learning (Marrucci et al., 2022; Aboelmaged & Hashem, 2019). Ultimately, embedding environmental values into the core organizational identity fosters a culture that sustains long-term commitment to green goals beyond immediate financial calculations (Celestin & Dorcas, 2024).

Economic and Competitive Incentives

Compelling economic and competitive incentives are powerful enablers. Direct cost savings from improved resource efficiency, energy conservation, and waste reduction provide a clear financial rationale for adoption (Hojnik & Ruzzier, 2016; Triguero et al., 2014). Beyond efficiency, green technologies offer strategic market advantages, including product differentiation, enhanced brand reputation, and access to new customer segments and revenue streams driven by growing demand for sustainable products (Bag et al., 2022; Demirel & Danisman, 2019). A forward-looking pursuit of innovation-based competitive advantage also motivates early experimentation, allowing SMEs to build capabilities ahead of tightening regulations or shifting market expectations (Saez-Martinez et al., 2016).

External Support and Policy Instruments

Effective external support mechanisms are crucial for mitigating SME-specific constraints. Financial instruments, such as grants, subsidies, and tax incentives, directly alleviate capital constraints and improve perceived returns on investment (Aristei & Gallo, 2021; Bakar et al., 2020). Informational and technical support, including advisory services, extension programs, and technology demonstrations, addresses critical knowledge gaps and reduces implementation complexity (Zhou et al., 2015; Klewitz et al., 2012). Furthermore, well-designed regulatory frameworks that are clear, stable, and performance-based (rather than prescriptive) reduce uncertainty and support long-term strategic planning for environmental upgrades (Ren & Albrecht, 2023; Triguero et al., 2013).

Collaboration and Knowledge Networks

Collaborative networks provide essential resources that SMEs lack internally. Formal partnerships with universities, research institutions, and technology providers grant access to specialized knowledge and innovation assets (Yoshino et al., 2025; Triguero et al., 2015). Supply chain partnerships are increasingly driven by larger firms imposing environmental standards on suppliers, simultaneously creating pressure and offering technical support for adoption (Bag et al., 2022). Industry clusters and networks facilitate valuable knowledge spillovers and reduce individual learning costs through shared experience (Segarra-Blasco et al., 2024). Emerging digital platforms, such as innovation hubs and online marketplaces, further democratize access to expertise and partners, transcending geographical limits and representing a new frontier for collaborative enablement (Spigarelli et al., 2025).

Synthesis of Barriers and Enablers

The key barriers and enablers identified in the literature are synthesized in Table 1, providing a consolidated reference before examining their complex interactions.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XI November 2025

Table 1. A thematic synthesis of primary barriers and enablers influencing green technology adoption in SMEs, with representative citations.

Category	Sub-Category / Theme	Description / Key Insight	Representative Citations
BARRIERS	**Financial & Economic Constraints**	High upfront investment costs, limited access to capital/credit, uncertain ROI, and perceived high risk deter investment, the most acute barrier, especially in emerging economies.	Fahad et al. (2022); Wielgorka & Szczepaniak (2019); Rybarova et al. (2023)
	Knowledge & Capability Gaps	Lack of technical expertise, awareness of technologies/regulations, and internal R&D capacity creates information asymmetry and impedes evaluation/implementation.	Ansari & Kant (2021); Shahin et al. (2024); Saez-Martinez et al. (2016)
	Regulatory & Institutional Hurdles	Complexity, instability, or weak enforcement of environmental regulations increases compliance burden. Corruption can distort incentives.	Garcia-Quevedo et al. (2020); Le Thanh Ha et al. (2021)
	Organizational & Managerial Challenges	Lack of leadership commitment, short-term focus, resistance to change ("if it is not broken..."), and flat structures lacking strategic planning capacity.	Fernandez-Muniz et al. (2024); Isensee et al. (2020); Mitchell et al. (2020)
ENABLERS	**Internal Drivers &** **Internal Capabilities**	Strong managerial environmental values/commitment, strategic vision, and a culture integrating sustainability into organizational identity. Absorptive capacity, investments in employee skills/training, and organizational learning processes that enable technology assimilation.	Han & Chen (2021); Hojnik & Ruzzier (2016); Celestin & Dorcas (2024) Marrucci et al. (2022); Aboelmaged & Hashem (2019
	Economic & Competitive Incentives	Direct cost savings (energy, waste), new market opportunities, product differentiation, enhanced brand reputation, and first-mover advantage.	Hojnik & Ruzzier (2016); Bag et al. (2022); Demirel & Danisman (2019)
	External Support & Policy	Grants, tax incentives, technical advisory services, demonstration projects, and clear, stable regulatory frameworks that de-risk investment.	Aristei & Gallo (2021); Bakar et al. (2020); Zhou et al. (2015); Ren & Albrecht (2023)
	Collaboration & Networks	Partnerships with universities, supply chain linkages with large firms, industry clusters, and digital platforms that provide knowledge, resources, and support.	Yoshino et al. (2025); Bag et al. (2022); Segarra-Blasco et al. (2024); Spigarelli et al. (2025)

An Integrative View: The Interplay of Barriers and Enablers

Contextual Variations in Influence Patterns

The influence of specific barriers and enablers varies substantially across contexts, resulting in distinct adoption patterns in each setting. Developed economies generally have more advanced regulatory systems, greater access

to financing, and stronger innovation ecosystems, making knowledge and organizational factors relatively more significant as barriers to entry (Marin et al., 2015). In contrast, emerging economies face more basic challenges related to institutional quality, capital availability, and infrastructure (Austin et al., 2025).

Sectoral characteristics also shape adoption patterns. Manufacturing SMEs face unique challenges compared to service firms, with differences in technology costs, production integration, and regulatory compliance across industries (Triguero et al., 2015), the technological intensity of sectors further influences which factors are most important.

Firm size and age bring additional differences. Micro-enterprises face challenges distinct from those of small or medium-sized firms, with resource constraints becoming more severe at more minor scales (Pronti et al., 2024). Startups and established companies also exhibit different adoption patterns, reflecting their unique organizational structures and strategic priorities (Srisathan et al., 2025).

Dynamic Interactions and Cumulative Effects

Barriers and enablers interact dynamically, leading to nonlinear adoption patterns that are hard to explain. Financial constraints often worsen other barriers because limited resources restrict investments in knowledge development, regulatory compliance, and organizational change (Gupta & Barua, 2018). On the other hand, strong internal enablers can help overcome multiple barriers simultaneously through targeted resource allocation and continuous effort.

The sequence of factors also influences adoption paths. Early successes with simple technologies can boost confidence and develop skills for more complex projects, creating positive cycles of progress (Saez-Martinez et al., 2016). Failures, on the other hand, can reinforce cautious attitudes and add additional obstacles through negative learning.

Threshold effects further complicate adoption patterns. Some barriers emerge only after certain stages of adoption, whereas others become less significant as firms gain experience and capabilities (Kiefer et al., 2021). Understanding these dynamic pathways is crucial for designing effective interventions.

Emerging Trends and Evolving Landscapes

Several emerging trends are reshaping the landscape of barriers and enablers for SME green technology adoption. Digitalization creates new opportunities through innovative technologies, data analytics, and platform-based business models, thereby reducing adoption costs and risks (Spigarelli et al., 2025). The merging of green and digital transitions represents an emerging development.

The circular economy paradigm is also evolving how adoption is viewed. Moving beyond pollution control to emphasize resource optimization creates new business opportunities and implementation requirements (Kiefer et al., 2021). SMEs engaged in circular business models often identify new revenue streams that affect their adoption decisions.

Changing stakeholder expectations also influences adoption patterns. Growing investor emphasis on environmental, social, and governance (ESG) factors, consumer demand for sustainable products, and employee values related to corporate responsibility create new incentives for investing in green technology (Demirel & Danisman, 2019). These shifting pressures make adoption even more essential for business success.

Critical Synthesis and Contradictions

While this review synthesizes prevalent themes, a critical examination reveals important contradictions and gaps. For instance, the role of external pressure is ambiguous: while some studies highlight stringent regulations as a key driver (García-Quevedo et al., 2020), others in emerging economies find that weak enforcement and corruption can paradoxically incentivize superficial compliance (Ha et al., 2021). Methodologically, the overreliance on cross-sectional surveys in the extant literature limits causal inference regarding the sequence of

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XI November 2025

adoption drivers. Furthermore, cultural and institutional contexts significantly moderate relationships; for example, managerial commitment, a robust enabler in Western contexts, may be less decisive in settings where access to technology or capital is the absolute constraint. These contradictions underscore the non-linear and context-dependent nature of green technology adoption, suggesting that future research should move beyond universal models to investigate conditional and configurational pathways.

An Integrative Conceptual Framework

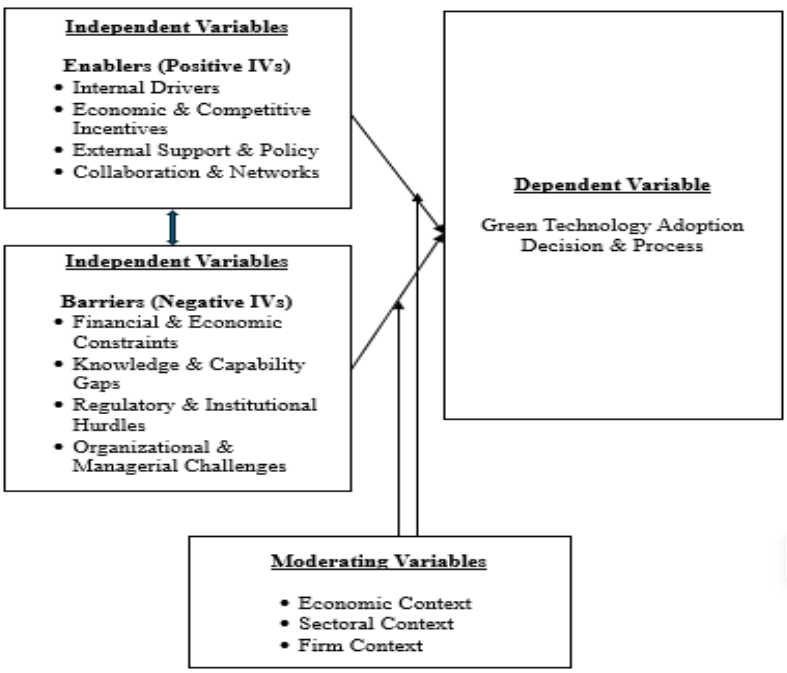
Based on the thematic synthesis, we propose an integrative framework (Figure 2) that classifies the key factors into dependent, independent, and moderating variables (see summary in Table 2). The central outcome, Green Technology Adoption Decision & Process, is directly influenced by a set of independent variables categorized as Barriers (which exert adverse effects) and Enablers (which exert positive effects). Critically, these relationships are not universal but are conditioned by Moderating Variables at the economic, sectoral, and firm levels. Furthermore, the framework posits dynamic interactions between barriers and enablers, as well as feedback loops from adoption outcomes to the firm's internal and external contexts.

Figure 2 illustrates this framework, depicting the proposed causal and moderating relationships. The model positions Green Technology Adoption Decision & Process as the central dependent variable (DV), directly impacted by Barriers (negative IVs) and Enablers (positive IVs). The moderating layer of Economic, Sectoral, and Firm Context shapes the strength and direction of these IV-DV relationships. Two-way arrows between Barriers and Enablers denote their dynamic interplay. In contrast, feedback arrows from the DV back to the IVs represent the longitudinal learning and resource effects of the adoption process itself.

Table 2 presents the variable definitions and hypothesized relationships underlying Figure 1. It details the specific constructs within each category (DV, IVs, MVs) and explicitly states testable hypotheses regarding their direct, moderating, and interactive effects on adoption. This table serves as a reference to operationalize the constructs within the framework and guides future empirical validation.

Together, Figure 2 and Table 2 translate the complex thematic findings of this review into a testable conceptual model. This framework moves beyond a static listing of factors by explicitly proposing how (direct influence), when (contextual moderation), and through what dynamics (interactions and feedback) these factors collectively shape the adoption journey in SMEs.

Figure 2. An integrative framework of the dynamic interactions shaping green technology adoption in SMEs.



ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XI November 2025

The model visually summarizes the core argument of this review. The central dependent variable (DV), Green Technology Adoption Decision & Process, is directly influenced by independent variables (IVs) categorized as Barriers (negative influence) and Enablers (positive influence). The strength and nature of these relationships are moderated (MVs) by the Economic, Sectoral, and Firm Context. The framework also proposes dynamic IV-IV Interactions between barriers and enablers and longitudinal Feedback Loops from adoption outcomes back to the firm's context and capabilities. See Table 2 for detailed variable definitions and hypotheses.

Table 2. Variable definitions for the conceptual framework of green technology adoption in SMEs

Variable Role	Construct Category	Specific Construct / Variable	Definition & Hypothesis
DEPENDENT VARIABLE (DV) *(The Outcome)*	**Adoption Outcome**	Green Technology Adoption Decision & Process	The central phenomenon to be explained. Refers to the extent, speed, and nature of an SME's commitment to and integration of green technologies. Operationalized as: Degree of adoption, implementation success, scale of investment, or innovation radicalness.
INDEPENDENT VARIABLES (IVs) *(The Direct Influences)*	**Barriers (Negative IVs)**	• Financial & Economic Constraints • Knowledge, Capability & Resources Limitations • Regulatory, Institutional & Market Barriers • Organizational & Managerial Challenges	Factors that directly and negatively influence the likelihood or extent of the DV (Adoption). **Hypothesis (H1)**: Higher levels of these barrier constructs are associated with lower levels of green technology adoption.
	Enablers (Positive IVs)	• Internal Drivers • Economics & Competitive Incentives Capabilities • External Support & Policy Instruments • Collaboration & Knowledge Networks	Factors that directly and positively influence the likelihood or extent of the DV (Adoption). **Hypothesis (H2)**: Higher levels of these enabler constructs are associated with higher levels of green technology adoption.
MODERATING VARIABLES (MVs) *(The Contextual Conditions)*	**Contextual Layers**	• Economic context • Sectoral context • Firm Context	Conditions that change the strength or direction of the relationship between the IVs (Barriers/Enablers) and the DV (Adoption). They set the boundary conditions. **Hypothesis (H3):** The relationship between barriers/enablers and adoption is moderated by (varies according to) economic, sectoral, and firm-level contexts.

RELATIONAL DYNAMICS	**Interactions**	**IV-IV Interaction** (Barrier-Enabler Interplay)	The interaction between independent variables. The effect of one IV (e.g., a Financial Barrier) on the DV may depend on the level of another IV (e.g., External Support). **Hypothesis (H4):** The adverse effect of barriers on adoption is attenuated (weakened) in the presence of strong enablers.
		Feedback Loop	Represents a longitudinal process where the DV (Adoption) influences the future state of the IVs, creating a non-linear, evolutionary path. **Hypothesis (H5):** Successful adoption increases internal capabilities and access to networks, thereby reducing future barriers and enhancing future enablers.

CONCLUSION AND IMPLICATIONS

Theoretical Contributions

This review makes several important theoretical contributions to understanding green technology adoption in SMEs. First, it develops an integrated framework that captures the multifaceted nature of adoption factors, moving beyond simple barrier-enabler distinctions to recognize complex interactions and contextual differences. Second, it describes dynamic pathways through which adoption processes evolve, highlighting the significance of sequence, cumulative effects, and learning. Third, it consolidates emerging trends reshaping the adoption landscape, particularly the convergence of green and digital transitions.

The review also deepens theoretical understanding by highlighting underexplored links among categories of factors. The interaction between internal capabilities and external support, for instance, appears more complex than is usually acknowledged, with complementary and substitution effects that vary across contexts. Similarly, the connection between various types of innovations, incremental versus radical, product versus process, and their influencing factors requires a more detailed theoretical analysis.

By synthesizing evidence from studies grounded in Institutional Theory, the Resource-Based View, and the Diffusion of Innovations, this review provides an integrated framework that bridges macro-level pressures, firm-level resources, and innovation-specific characteristics, offering a more holistic theoretical explanation for green technology adoption in SMEs.

Practical Implications for SME Managers

SME managers can gain several practical insights from this review. First, developing internal capabilities through strategic hiring, employee training, and organizational learning establishes a solid foundation for successful adoption. Second, actively engaging with external networks, including industry associations, research institutions, and government programs, provides access to resources beyond the company's boundaries. Third, employing staged approaches that begin with lower-risk technologies can help build experience and confidence for more ambitious projects.

Strategic prioritization is also crucial. Instead of attempting to implement comprehensive sustainability overhauls, SMEs may achieve better results by focusing on technologies aligned with their core business goals that provide tangible competitive advantages. Integrating environmental considerations into existing business processes, rather than treating them as separate initiatives, is generally more effective and sustainable.

Policy Implications

Policymakers can leverage several insights from this review to develop more effective support programs. First, combining multiple policies that address different barriers, such as financial aid, technical assistance, and regulatory simplification, generally works better than relying on just one approach. Second, tailoring interventions to specific SME segments, taking into account factors such as size, sector, and capabilities, enhances their relevance and effectiveness. Third, creating collaborative platforms that encourage knowledge sharing and joint efforts can increase the impact of public investments.

Policy sequencing also warrants attention. Initial efforts might focus on raising awareness and developing capabilities, followed by financial incentives for adoption, and eventually by transitioning to performance-based regulations that reward outcomes rather than specific technologies. This phased approach aligns support with the evolving needs throughout the adoption stages.

Avenues for Future Research

This review highlights several promising directions for future research. First, longitudinal studies tracking adoption processes over time could reveal dynamic interactions and causal relationships that are hidden by cross-sectional research designs. Second, comparative studies across different economic contexts would improve understanding of how macroeconomic conditions and institutional frameworks influence adoption patterns. Third, exploring emerging technology fields, mainly digital technologies that support green transitions, would fill important knowledge gaps.

Methodological innovation also offers numerous opportunities. Multilevel modeling techniques can more effectively capture nested influences at the individual, organizational, and ecosystem levels. Qualitative comparative analysis (QCA) may identify combinations of conditions associated with successful adoption. Participatory action research approaches could generate more practically relevant insights through collaborative knowledge creation with SME stakeholders.

Finally, advancing theoretical development remains a vital frontier. Integrating insights from innovation studies, organizational behavior, institutional theory, and sustainability transitions would produce more comprehensive explanations of green technology adoption in SMEs. This type of theoretical integration would not only improve academic understanding but also aid in designing more effective interventions to accelerate sustainability transitions in the important SME sector.

CONCLUSION

This narrative review systematically examined the complex landscape of factors influencing the adoption of green technology in SMEs, synthesizing evidence from 122 studies across diverse contexts and theoretical perspectives. It confirms that while SMEs face significant and multifaceted barriers, most notably financial constraints, knowledge gaps, regulatory complexities, and organizational inertia, they are also driven by a variety of internal and external enablers, from managerial commitment and competitive incentives to policy support and collaborative networks. Significantly, the review goes beyond simply listing factors by explaining their dynamic interactions, contextual dependencies, and evolving nature amid trends such as digitalization and the circular economy.

Ultimately, accelerating the green transition in the important SME sector requires focused and coordinated efforts. It requires strategic management that develops internal capabilities and leverages external networks, along with careful policymaking that tailors support to specific situations and firm profiles. By integrating insights from institutional theory, the resource-based view, and the diffusion of innovations into a testable framework, this review provides a clear foundation for future research and a practical plan for stakeholders seeking to promote sustainable innovation in SMEs worldwide.

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