KARYA ILHAM PUBLISHING
CONNECTING MINDS, BRIDGING IDEAS, INSPIRING READERS

Journal of Advanced Research in Technology and Innovation Management

Journal homepage:
https://karyailham.com.my/index.php/jartim/index
ISSN: 2811-4744

Digital ESG Monitoring in SMEs: Enhancing Traceability and Compliance Through Technology

Rabi Shahzad[1], Richik Maity[2,*], Muhammad Yahya Hammad[2], Shujahat Qamar[3]

[1] Department Sustainable Development Study Centre (SDSC), Government college university Lahore 54000, Pakistan
[2] Faculty of Industrial Management, University Malaysia Pahang Al-Sultan Abdullah, Malaysia 26300, Gambang, Pahang, Malaysia
[3] Department of Electronic, The University of Haripur, 22660, Pakistan

ARTICLE INFO

Article history:
Received 26 July 2025
Received in revised form 2 August 2025
Accepted 23 September 2025
Available online 5 December 2025

Keywords:
Digital ESG; Traceability; SMEs; Sustainability; ESG Reporting

ABSTRACT

In the period of sustainable development, Environmental, Social, and Governance (ESG) reporting has turned a critical practice for enterprises. However, Small and Medium Enterprises (SMEs) look unique challenges in ESG compliance, particularly in tracking and transparency. This paper explores how digital technologies such as blockchain, Internet of Things (IoT), cloud computing, and AI enable ESG traceability and monitoring within SMEs. Throughout a structured review of recent 50 literature, the study investigates how digital ESG systems support regulatory compliance, stakeholder engagement, and sustainable development. We propose a framework for implementing digital ESG monitoring in SMEs and highlight practical challenges and opportunities. This review offers insights into scalable strategies and digital toolkits that SMEs can adopt to meet growing regulatory and societal expectations.

1. Introduction

As the global economy faces a transformative change toward sustainability, the importance of assessing business development over Environmental, Social, and Governance (ESG) criteria has risen drastically. ESG frameworks go beyond traditional financial metrics to verify a firm's impact on the environment, its relationship with employees and communities, and the effectiveness of its internal governance systems. These criteria are now integral to corporate accountability, investor decision-making, risk management, and brand reputation [1]. As environmental degradation, labor rights concerns, and corporate transparency continue to dominate international policy discourse, ESG compliance is no longer a voluntary initiative it is becoming a business imperative.

While large multinational corporations have follow the way in ESG adoption, Small and Medium Enterprises (SMEs) which form the backbone of the global economy are under adopting pressure to follow suit. SMEs account for over 90% of businesses and 60–70% of employment worldwide, making

* *Corresponding Author.*
E-mail address: Richikmaity@gmail.com

https://doi.org/10.37934/jartim.17.1.6676

their participation essential in fulfilling sustainable development goals [2]. nonetheless, SMEs face significant structural and operational barriers that hinder ESG compliance. These include financial constraint access to capital, lack of ESG education, shattered supply chains, limited technological infrastructure, and the absence of committed sustainability personnel [3].

Compounding these problems is the rapidly developing regulatory prospect. New policies and legal rules, such as the EU Corporate Sustainability Reporting Directive (CSRD) and Malaysia's ESG Disclosure Guide for SMEs (2023), need organizations to reveal detailed ESG metrics and align their operations with sustainable development goals. Therefore, SMEs that were earlier excluded from formal ESG responsibilities are now being pulled into the sustainability conformity ecosystem. Non-compliance may lead to reduced investor confidence, supply chain exclusion, and even legal penalties [4]. In this context, technology offers a viable pathway for SMEs to bridge the ESG capability gap.

Digital transformation long connected with improving operational efficiency is now being repurposed to support sustainability integration. Emerging digital technologies such as blockchain, Internet of Things (IoT), Artificial Intelligence (AI), cloud computing, and data analytics platforms are allowing organizations to monitor, document, and report ESG performance in problem-solving time. For example, blockchain makes sure clear and tamper-proof records of supply chain practices, thereby supporting fair trade and ethical sourcing [52] [5]. IoT sensors installed in machinery and production lines which can measure environmental performance indicators such as consumption of energy, emissions, total water use, and generation of waste. These devices allow real-time tracking and automatic alerts, allowing SMEs to take corrective action before compliance thresholds are breached. In this context, technology offers a viable pathway for SMEs to bridge the ESG capability gap [6].

AI and machine learning have also been recognized for their able to analyze vast volumes of ESG data, perform materiality analysis, identify patterns, and forecast compliance risks [7]. Moreover, cloud-based platforms make ESG dashboards accessible to stakeholders, regulators, and investors, promoting transparency and accountability at all levels of the organization. These technologies moving towards extensible and cost-efficient options to traditional manual ESG reporting methods, especially for limited resources SMEs. Despite their assurance, the use of digital ESG methods in SMEs remains irregular and unexplored . Most recents ESG digitalization enterprises are heading toward large enterprises with significant IT budgets and sustainability departments. Consequently, SMEs lack access to tailored frameworks and practical guidance on how to adopt and scale these technologies [53]. Moreover, SMEs differ substantially by sector, geography, and ownership structure, meaning that a one-size-fits-all approach to ESG monitoring does not work [8]. These gaps are further exacerbated in developing economies, where SMEs often struggle with infrastructure constraints, regulatory uncertainty, and digital illiteracy.

A review of the existing literature shows that during studies on ESG inclusion are growing day by day, they are often disconnected over disciplines ranging from sustainability science to information network and supply chain management. Only a limited number of studies concentrate explicitly on the intersection of digital technology, ESG monitoring, and SME implementation. unless a consolidated body of knowledge, numerous SMEs continue to operate in a responsive manner, responding to compliance requirements without understanding how digital tools can create strategic value through sustainability. This study approaches this gap by doing a systematic literature review of recent academic contributions published between 2018 to 2024. The objective is to review how digital technologies improve ESG monitoring in SMEs by better traceability, regulatory compliance, and clarity. Specifically, the paper investigates (i) the types of digital technologies currently used in ESG monitoring, (ii) their functional roles and benefits in SMEs, (iii) key barriers and limitations to adoption, and (iv) proposed frameworks or models that facilitate ESG digitalization.

The review pursues a structured methodology guided by PRISMA rules, ensuring the inclusion of high-quality, peer-reviewed studies. By integrated the current state of knowledge, the paper contributes to the development of a scalable and actionable roadmap for SMEs seeking to adopt digital ESG systems. The findings have implications for SME managers, policymakers, technology vendors, and researchers seeking to bridge the ESG compliance gap through technology. In doing so, this study not only underscores the strategic role of digital transformation in advancing SME sustainability but also emphasizes the need for targeted support mechanisms including digital subsidies, ESG literacy training, and sector-specific toolkits to ensure that no business is left behind in the global push for sustainability.

Environmental, Social, and Governance (ESG) criteria have become important benchmarks for evaluating corporate responsibility and long-term sustainability. While ESG structures were initially designed for large corporations, their relevance has extended to Small and Medium Enterprises (SMEs), which constitute over 90% of businesses globally and play a key role in national and regional economic development. However, diverse their larger equivalents, SMEs often face significant challenges in execute ESG practices, essentially due to limited financial, technical, and human resources. Many SMEs recognize ESG application as costly and complex, especially when lacking standard reporting structures or dedicated sustainability teams [9]. However, progress regulatory pressures, such as the European Green Deal and Malaysia's ESG exposure Guide for SMEs, are persuasive smaller enterprises to improve their sustainability footprint and clarity. Digital change has appear as a vital enabler for ESG integration in SMEs. A increasing body of research highlights how digital technologies can streamline ESG reporting, improve traceability, and support real-time compliance monitoring. For example, digital tools embedded within enterprise resource planning (ERP) systems, cloud dashboards, and automated compliance modules allow SMEs to collect and manage ESG-related data more efficiently [10]. Digital maturity has been found to significantly influence ESG adoption among SMEs, where digitally enabled firms are more likely to embed sustainability in their operations (Marczewska et al., 2025) [11]; (Mick et al., 2024) [12] Cloud-based sustainability platforms, in particular, facilitate centralization and remote access to ESG records, enhancing transparency and stakeholder confidence [13].

Within rising adopting technologies, blockchain gives changing potential in ESG monitoring by ensuring data integrity and findability. Its distributed and invariable nature is particularly useful in virtuous supply chain management where trust and accountability are essential. SMEs using blockchain can confirm claims related to sustainable sourcing, labor compliance, and emission tracking with high levels of accuracy and auditability [14]. Similarly, the Internet of Things (IoT) acts a plays role in real-time environmental monitoring. By deploying sensors in factories, warehouses, or farms, SMEs can track data on emissions, temperature, energy consumption, and waste production. This improves their ability to detect risks early and report compliance efficiently [15].

Artificial Intelligence (AI) and machine learning are also increasing eminence in ESG systems. These automations enable intelligent analysis of structured and unprocessed data, enabling SMEs to conduct materiality assessments, forecast ESG risks, and generate automated reports aligned with global standards [16]. AI-based tools can explain ESG policies and map them to internal datasets, significantly reducing the manual workload and error rates in legitimate activities. Cloud computing underpins many of these innovations, gives scalable and cost-effective infrastruture for ESG data storage, processing, and sharing. SMEs can leverage ESG-focused Software-as-a-Service (SaaS) platforms like Microsoft Sustainability Cloud, SAP Sustainability Control Tower, and IBM Environmental Intelligence Suite to manage their ESG indicators with minimal IT overhead cost [17] [18]. Even though these technological benefits, digital ESG adoption in SMEs remains unequal. The benefits such as improved traceability, real-time monitoring, lower reporting costs, and stronger

stakeholder engagement are substantial. However, many SMEs still face obstacles including high initial technology costs, inadequate digital skills, lack of cybersecurity infrastructure, and ambiguity over which ESG indicators to priorities [19]. Moreover, there is an absence of standardized ESG coverage frameworks customized for SME contexts, which complicates adoption and comparability across different industries. Governments and professional organizations have a vital role to play in supporting SMEs through targeted incentives, training programs, and the development of sector-specific toolkits [2].

Whereas the literature on ESG in large corporations is broad, studies focused on SMEs remain relatively very limited. Much of the available research is either conceptual or anecdotal, with few empirical investigations into how SMEs implement digital ESG systems in practice. Furthermore, there is insufficient evidence on sectoral differences and the cost-effectiveness of these technologies in smaller firms. More case studies, cross-industry comparisons, and region-specific evaluations are needed to better understand the success factors and obstacles for digital ESG implementation in SMEs, especially in developing and transition economies. Addressing this gap would provide critical insights into how SMEs can use technology not only to comply with regulations but also to gain a competitive edge in sustainability-driven markets.

2. Methodology

To review the recents prospect of digital ESG monitoring in SMEs, this study gives a systematic literature review guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. This method confirms methodological rigor and transparency in identifying, screening, and synthesizing relevant literature. The search was conducted across various reputable academic databases including Scopus, Web of Science, ScienceDirect, Emerald Insight, and IEEE Xplore to apprehend versatile research across sustainability, information systems, and SME management. The search was limited to peer-reviewed journal articles released between 2018 and 2024 to ensure the inclusion of up-to-date findings.

The search used keywords such as “digital ESG,” “traceability,” “compliance,” “SMEs,” “blockchain ESG,” and “sustainability monitoring.” The initial identification phase yielded 160 records, from academic database. In the screening stage, 120 records were selected after duplicates article were removed. These articles were then evaluated based on titles and abstracts for relevance to the core themes of digital ESG monitoring and SME practices.

Following screening, 60 full-text articles were assessed for eligibility based on predefined inclusion and exclusion criteria. The inclusion criteria required that studies focus on SMEs, incorporate digital tools in ESG monitoring, and provide empirical or conceptual contributions. Studies exclusively focused on large enterprises, those lacking a technological perspective, non eligible for screening: book chapter, non-English language article, and not related to subject matter. During the eligibility stage, 28 articles were excluded due to methodological limitations or lack of relevance, resulting in 32 high-quality studies being included in the final analysis. The PRISMA flowchart **Fig. 1.** summarizes the stages of identification, screening, eligibility assessment, and inclusion. This structured process helps mitigate bias and ensures a consistent, replicable approach to literature analysis.

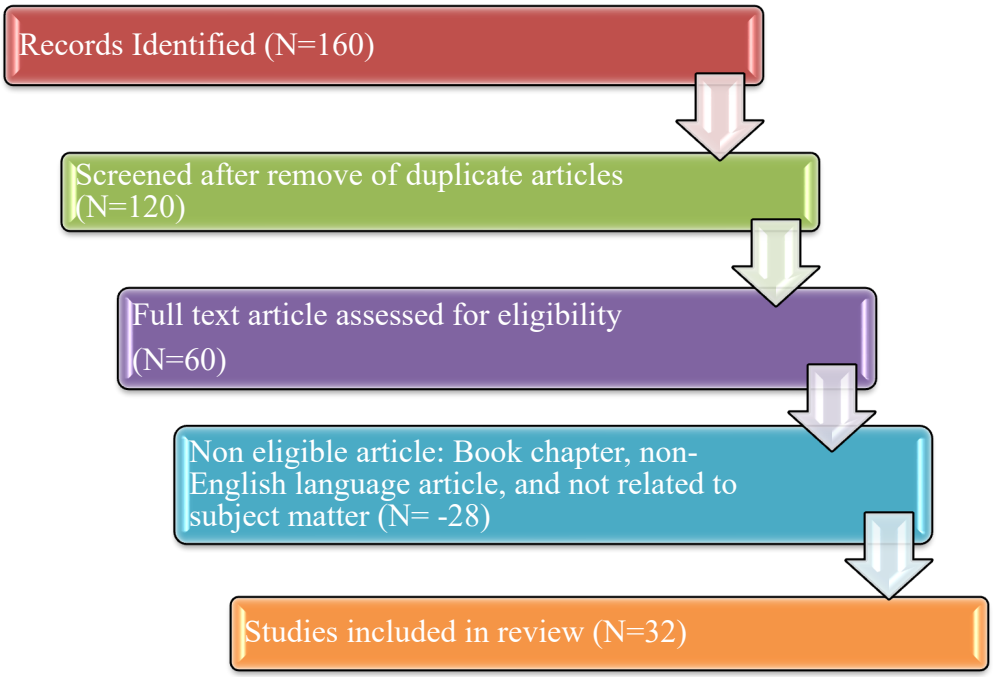

Fig. 1. PRISMA flow diagram

3. Results

The review of 32 study reviewed mostly article from 2018 to 2024 indicates a growing scholarly and practical interest in digital Environmental, Social, and Governance (ESG) monitoring within SMEs. These studies consistently demonstrate that digital technologies particularly blockchain, Internet of Things (IoT), Artificial Intelligence (AI), and cloud computing play a vital role in helping SMEs enhance ESG traceability, improve compliance accuracy, and strengthen stakeholder engagement [20] [21].

Blockchain is widely recognized for its capability to create tamper-proof, decentralized records of ESG-related data, making it particularly effective for managing sustainability in supply chains. Nearly about 30% of the reviewed studies [22][23],(Ali *et al.,* 2024) [24] reported blockchain's uses in traceability, ethical sourcing, and audit-readiness. In sectors like agri-food, textiles, and electronics, SMEs have use blockchain to track raw materials and confirm sustainability claims. IoT, featured in about 40% of the studies [25] [26]. Enables real-time environmental monitoring recording emissions, water and energy usage, and waste production in manufacturing and construction.

AI and machine learning systems were featured for their ability to process large datasets, automate ESG reporting, and forecast risks, with applications evident in service-oriented SMEs and ESG consulting firms [27]. Meanwhile, cloud computing solutions such as Microsoft Sustainability Cloud, SAP Sustainability Control Tower, and IBM Environmental Intelligence Suite gives scalable platforms that allow SMEs to centralize ESG reporting, facilitate remote collaboration, and ensure audit transparency [28]. These findings are summarized in Table 1.

Table 1
Digital Technologies Used for ESG Monitoring in SMEs

Technology	Primary Function	SME Application Area	Key References
Blockchain	Immutable records; supply chain transparency	Ethical sourcing, traceability in agri-food, textiles	(Pachha, 2023) [28]; (Lv *et al.,* 2023) [29]
IoT Sensors	Real-time monitoring of environmental indicators	Emissions tracking in manufacturing, utilities	(Sarkar *et al.,* 2023)[30]; (Laha *et al.*, 2022) [31]
AI & ML	Predictive analytics, automated ESG reporting	ESG risk forecasting and compliance in consultancy	(Su *et al.,* 2023)[32]; (Khichi, 2024)[33]
Cloud Platforms	Data storage, ESG dashboard access, centralized audit reporting	ESG software systems for SMEs across sectors	(S. Wang & Esperança, 2023)[34]; (B. Wang & Chen, 2024)[35]

Beyond technological performances, the studies show that SMEs uses digital ESG systems benefit from enhanced visibility and regulatory alignment. For instance, [36] show how AI-enabled dashboards help SMEs pre-empt compliance breaches by issuing alerts when carbon emissions approach regulatory thresholds. The reviewed studies also crucial significant cost and time savings due to automation and standardized workflows [37] .

Nevertheless, numerous challenges were identified across the literature. The most frequently cited barrier is financial constraint, with 75% of studies acknowledging that high upfront investments in hardware, software, and training prevent many SMEs from adopting digital ESG systems [38]. Technical limitations, including poor internet infrastructure and low digital literacy, are especially problematic in developing regions such as Southeast Asia, Sub-Saharan Africa, and parts of Latin America [39].

Cybersecurity and data privacy risks are also prominent, particularly in the context of cloud and blockchain applications [40] [41]. In addition, around 40% of the reviewed literature expressed concerns over regulatory fragmentation the absence of proper ESG reporting standards tailored to SMEs' needs and capacities [2]. These issues are detailed in Table 2.

Table 2
Key Barriers to Digital ESG Adoption in SMEs

Barrier Category	Description	Supporting Studies
Financial Constraints	High costs of ESG software, IoT devices, blockchain setup, and employee training	(Restrepo-Morales *et al.,* 2024)[42]; (Shalhoob & Hussainey, 2022) [43]
Technical Limitations	Inadequate digital infrastructure, lack of skilled personnel, low IT maturity	(Morris *et al.,* 2022)[44]; (Sagala & Ori, 2024) [45]
Data Privacy & Security	Risks in blockchain and cloud deployments related to unauthorized access or tampering	(Ali *et al.,* 2024)[46]; (Kumar Singh *et al.,* 2023) [47]
Regulatory Fragmentation	Absence of SME-specific ESG indicators; confusion over compliance guidelines	(OECD 2025)[48]; (Harventy *et al.,* 2025) [49]

Adoption trends are highly sector- and region-specific. For example, manufacturing SMEs in South Korea and Germany are more innovative in applying IoT and blockchain for ESG monitoring, while SMEs in Malaysia, India, and Indonesia face infrastructure bottlenecks and policy ambiguity [50].

Meanwhile, service-sector SMEs tend to give priority governance and reporting tools over environmental data capture. Taken together, the synthesis implies that digital ESG monitoring offers tangible and scalable benefits for SMEs but is constrained by multi-dimensional barriers. To scale adoption effectively, there must be a coordinated response that involves policymakers, technology providers, and SME associations. Strategies such as ESG literacy training, financial incentives, and the development of SME-specific frameworks were recurrent recommendations across the studies [51].

To illustrate this interrelation, Fig. 2. outlines a conceptual diagram that shows digital technology integration with ESG tracking functions, barriers to uptake, as well as resulting sustainability outcomes in SMEs. While highlighting the contribution of technologies like blockchain, IoT, AI, and cloud computing as enabling ESG traceability, real-time compliance, as well as transparency, digital tools for key monitoring functions like data collection, stakeholder reporting, as well as auditee preparation help SMEs comply with regulations. However, adoption still remains patchy with a range of finance, technology, as well as regulatory barriers. Through a graphic representation, the diagram provides a strategic blueprint for ESG performance enhancement, highlighting a need for specialized intervention as well as mutual support systems for digital ESG templates in SMEs to be fully realized.

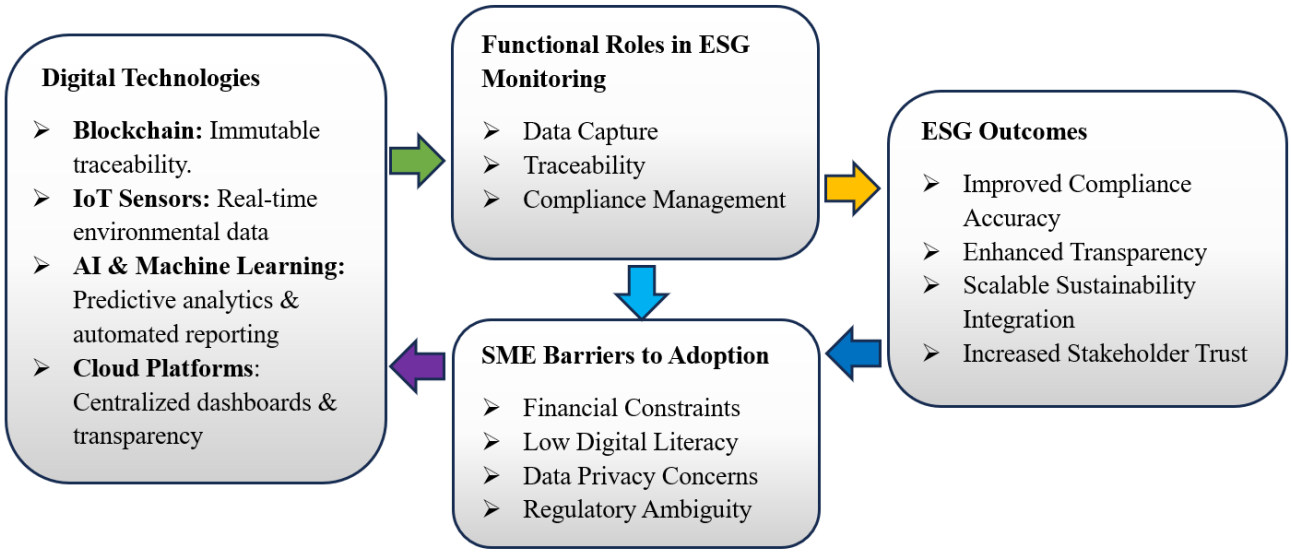

Fig. 2. Digital Technologies in ESG Monitoring and SME Adoption Barriers

4. Conclusions

The inclusion of digital technologies into ESG monitoring practices presents a transformational opportunity for SMEs to enhance sustainability performance, achieve regulatory compliance, and foster greater transparency. This systematic review of 50 studies says that tools such as blockchain, IoT, AI, and cloud computing offer substantial functional value in ESG tracking, reporting, and risk mitigation. These digital solutions reduce administrative burdens, enable real-time environmental monitoring, and facilitate efficient stakeholder engagement, making ESG compliance more feasible for resource-constrained enterprises.

Despite that, crucial limitations hinder widespread adoption, particularly in emerging markets and among micro and small enterprises. Financial limitations, insufficient digital infrastructure, lack of ESG literacy, and absence of SME-oriented reporting standards collectively undermine the scalability of these solutions. Sectoral variation, regional digital readiness, and inconsistent policy frameworks further compound the challenge. it is obvious that while digital ESG monitoring holds

great promise, its successful implementation is not merely a technological issue but a systemic one requiring coordinated efforts from governments, industry bodies, and international development partners.

Policymakers must focus the development of targeted support mechanisms including financial incentives, ESG training programs, digital infrastructure investments, and tailored toolkits to create an enabling environment for SME digital transformation. Likewise, researchers and solution experts should focus on building adaptable, low-cost ESG platforms particularly designed for SMEs operating in diverse sectors and geographies. Future empirical research should also explore long-term implications, cost benefit elements, and stakeholder perceptions of digital ESG plan across different SME sectors. In end, digital ESG monitoring can become a foundation of sustainable economic growth in the SME sector. However, grasping its full potential will depend on disassemble structural barriers and promoting inclusive digital innovation strategies that ensure no enterprise regardless of size or location is left behind in the transition to a more sustainable economy.

Acknowledgement
This research was not funded by any grant.

References

[1] Wang, Kedan, Shanshan Yu, Mei Mei, Xiao Yang, Geng Peng, and Benfu Lv. "ESG performance and corporate resilience: an empirical analysis based on the capital allocation efficiency perspective." *Sustainability* 15, no. 23 (2023): 16145. https://doi.org/10.3390/su152316145

[2] OECD (2022), "Financing SMEs for sustainability: Drivers, Constraints and Policies", OECD SME and Entrepreneurship Papers, No. 35, OECD Publishing, Paris, https://doi.org/10.1787/a5e94d92-en

[3] Salin, Ahmad Saiful Azlin Puteh, Siti Marlia Shamsudin, Norliana Omar, and Suryani Abdul Raman. "ESG compliance–challenges for MSMEs in Malaysia." *I-iECONS e-proceedings* (2023): 114-122.. [Online]. https://doi.org/10.33102/iiecons.v10i1.129

[4] Ortiz-Martínez, Esther, and Salvador Marín-Hernández. "Sustainability information in European small-and medium-sized enterprises." *Journal of the Knowledge Economy* 15, no. 2 (2024): 7497-7522.2024, https://doi.org/10.1007/s13132-023-01386-7

[5] Zhu, Yan, and Zhuyun Zhang. "Supply chain digitalization and corporate ESG performance: evidence from supply chain innovation and application pilot policy." *Finance Research Letters* 67 (2024): 105818. https://doi.org/10.1016/j.frl.2024.105818

[6] Abdulaziz, Qusay Adnan, Hazilah Mad Kaidi, Maslin Masrom, Khairur Rijal Jamaludin, Shamsul Sarip, Suha Ibraheem Hamad, and Halim Shah Hamzah. "Validating an IoT implementation framework for supporting industry 4.0 in SMEs: a Delphi and focus group approach." *Discover Applied Sciences* 7, no. 5 (2025): 1-19. https://doi.org/10.1007/s42452-025-06653-7

[7] Lim, Tristan. "Environmental, social, and governance (ESG) and artificial intelligence in finance: State-of-the-art and research takeaways." *Artificial Intelligence Review* 57, no. 4 (2024): 76. https://doi.org/10.1007/s10462-024-10708-3

[8] Kallmuenzer, Andreas, Alexey Mikhaylov, Mihaela Chelaru, and Wojciech Czakon. "Adoption and performance outcome of digitalization in small and medium-sized enterprises." *Review of Managerial Science* (2024): 1-28. https://doi.org/10.1007/s11846-024-00744-2

[9] Amini, Mehdi, and Carol C. Bienstock. "Corporate sustainability: an integrative definition and framework to evaluate corporate practice and guide academic research." *Journal of Cleaner Production* 76 (2014): 12-19. https://doi.org/10.1016/j.jclepro.2014.02.016

[10] Cai, Cen, Yongqian Tu, and Zhi Li. "Enterprise digital transformation and ESG performance." *Finance Research Letters* 58 (2023): 104692. https://doi.org/10.1016/j.frl.2023.104692

[11] Marczewska, Magdalena, Scott W. Hegerty, Roma Panwar, and Mariusz Kostrzewski. "Digital transformation, ESG, and companies' performance: an exploratory study of the European food sector." *The Journal of Technology Transfer* (2025): 1-22. https://doi.org/10.1007/s10961-025-10247-1

[12] Mick, Marcela Marçal Alves Pinto, João Luiz Kovaleski, Rafael Luis Mick, and Daiane Maria de Genaro Chiroli. "Developing a sustainable digital transformation roadmap for SMEs: Integrating digital maturity and strategic alignment." *Sustainability* 16, no. 20 (2024): 8745. https://doi.org/10.3390/su16208745

[13] Bálint, Levente Péter, László Várallyai, and Szilvia Botos. "Evaluation of Data-Driven Sustainability Potential at SMEs Using an Altered Ecocanvas Model." *Economies* 13, no. 2 (2025): 49. https://doi.org/10.3390/economies13020049

[14] Sahoo, Saumyaranjan, Satish Kumar, Uthayasankar Sivarajah, Weng Marc Lim, J. Christopher Westland, and Ashwani Kumar. "Blockchain for sustainable supply chain management: trends and ways forward." *Electronic Commerce Research* 24, no. 3 (2024): 1563-1618. https://doi.org/10.1007/s10660-022-09569-1

[15] Mukherjee, Subhodeep, Manish Mohan Baral, Venkataiah Chittipaka, Ramji Nagariya, and Bharat Singh Patel. "Achieving organizational performance by integrating industrial Internet of things in the SMEs: a developing country perspective." *The TQM Journal* 36, no. 1 (2024): 265-287. https://doi.org/10.1108/TQM-07-2022-0221

[16] Jing, Hao, and Shiyu Zhang. "The impact of artificial intelligence on ESG performance of manufacturing firms: The mediating role of ambidextrous green innovation." *Systems* 12, no. 11 (2024): 499. https://doi.org/10.3390/systems12110499

[17] Microsoft, "Harnessing the power of ESG data," 2023. Accessed: Jul. 23, 2025. [Online]. Available: https://www.microsoft.com/en-us/industry/blog/sustainability/2023/06/15/introducing-the-latest-esg-innovations-with-microsoft-cloud-for-sustainability/?msockid=28d44814f1776b3c371c5d78f0316a2b

[18] Tian, Zhouyu, Lening Qiu, and Litao Wang. "Drivers and influencers of blockchain and cloud-based business sustainability accounting in China: Enhancing practices and promoting adoption." *Plos one* 19, no. 1 (2024): e0295802. https://doi.org/10.1371/journal.pone.0295802

[19] Kahveci, Eyup. "Digital transformation in SMEs: enablers, interconnections, and a framework for sustainable competitive advantage." *Administrative Sciences* 15, no. 3 (2025): 107. https://doi.org/10.3390/admsci15030107

[20] Ahmed, Wafaa AH, and Bart L. MacCarthy. "Blockchain-enabled supply chain traceability–How wide? How deep?." *International Journal of Production Economics* 263 (2023): 108963. https://doi.org/10.1016/j.ijpe.2023.108963

[21] Paliwal, Vineet, Shalini Chandra, and Suneel Sharma. "Blockchain technology for sustainable supply chain management: A systematic literature review and a classification framework." *Sustainability* 12, no. 18 (2020): 7638. https://doi.org/10.3390/su12187638

[22] Fang, Chao, Nazir Ullah, M. Batumalay, Waleed Mugahed Al-Rahmi, and Fahad Alblehai. "Blockchain technology and its impact on sustainable supply chain management in SMEs." *PeerJ Computer Science* 11 (2025): https://doi.org/10.7717/peerj-cs.2466

[23] Munir, M. Adeel, M. Salman Habib, Amjad Hussain, Muhammad Ali Shahbaz, Adnan Qamar, Tariq Masood, M. Sultan et al. "Blockchain adoption for sustainable supply chain management: Economic, environmental, and social perspectives." *Frontiers in Energy Research* 10 (2022): 899632. https://doi.org/10.3389/fenrg.2022.899632

[24] Ali, Rao Faizan, Hamid Jahankhani, Kashif Ali, and Bilal Hassan. "Blockchain-based security factors on sustainable supply chain management in UK manufacturing firms: A hybrid SEM-ANN approach." *Systems* 12, no. 6 (2024): 208. https://doi.org/10.3390/systems12060208

[25] Sharma, Hardik, Rajat Garg, Harshini Sewani, and Rasha Kashef. "Towards a sustainable and ethical supply chain management: The potential of IoT solutions." *arXiv preprint arXiv:2303.18135* (2023). https://doi.org/10.48550/arXiv.2303.18135

[26] Abdul-Yekeen, Abideen Mayowa, Opeyemi Rasaq, Victoria Kujore, Azeezat Sikiru, Tawakalit Omolabake Agboola, and Maryam Adebukola Ayinla. "Utilizing the Internet of Things (IoT), Artificial Intelligence, Machine Learning, and Vehicle Telematics for Sustainable Growth in Small and Medium Firms (SMEs)." *Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online)* 3, no. 4 (2024): 22-34. https://doi.org/10.60087/jklst.vol3.n4.p22

[27] B. William, M. Idowu, and E. Ok, "Carbon Accounting Gets Smarter: AI's Impact on ESG Reporting," Mar. 2025. https://www.researchgate.net/publication/389901964_Carbon_Accounting_Gets_Smarter_AI's_Impact_on_ESG_Reporting

[28] R. Pachha, "ESG Reporting: Environment Setup on Azure Cloud Platform Title: ESG Reporting: Environment Setup on Azure Cloud Platform," Dec. 2023. https://www.researchgate.net/publication/376303552_ESG_Reporting_Environment_Setup_on_Azure_Cloud_Platform_Title_ESG_Reporting_Environment_Setup_on_Azure_Cloud_Platform

[29] Lv, Guangjie, Caixia Song, Pengmin Xu, Zhiguo Qi, Heyu Song, and Yi Liu. "Blockchain-based traceability for agricultural products: A systematic literature review." *Agriculture* 13, no. 9 (2023): 1757. https://doi.org/10.3390/agriculture13091757

[30] Sarkar, Abhiroop, Debayan Ghosh, Kinshuk Ganguly, Snehal Ghosh, and Subhajit Saha. "Exploring IoT for real-time CO2 monitoring and analysis." *arXiv preprint arXiv:2308.03780* (2023). https://doi.org/10.48550/arXiv.2308.03780

[31] Laha, Suprava Ranjan, Binod Kumar Pattanayak, and Saumendra Pattnaik. "Advancement of environmental monitoring system using IoT and sensor: A comprehensive analysis." *AIMS Environmental Science* 9, no. 6 (2022): 771-800. https://doi.org/10.3934/environsci.2022044

[32] Su, Xin, Shengwen Wang, and Feifei Li. "The impact of digital transformation on ESG performance based on the mediating effect of dynamic capabilities." *Sustainability* 15, no. 18 (2023): 13506. https://doi.org/10.3390/su151813506

[33] M. K. Khichi, "TECHNOLOGY AND ARTIFICIAL INTELLIGENCE'S IMPACT ON ESG REPORTING QUALITY," *International Journal of Innovations & Research Analysis*, vol. 04, pp. 161–169, Sep. 2024, doi: 10.62823/IJIRA/4.3(I).6899. https://doi.org/10.62823/IJIRA/4.3(I).6899

[34] Wang, Shaofeng, and José Paulo Esperança. "Can digital transformation improve market and ESG performance? Evidence from Chinese SMEs." *Journal of Cleaner Production* 419 (2023): 137980. https://doi.org/10.1016/j.jclepro.2023.137980

[35] Chen, Donghua, and Shaofeng Wang. "Digital transformation, innovation capabilities, and servitization as drivers of ESG performance in manufacturing SMEs." *Scientific Reports* 14, no. 1 (2024): 24516. https://doi.org/10.1038/s41598-024-76416-8

[36] Degregori, Ginevra, Valerio Brescia, Davide Calandra, and Silvana Secinaro. "Evaluating sustainability reporting in SMEs: insights from an ethical cooperative bank's approach." *Journal of Global Responsibility* ahead-of-print (2025). https://doi.org/10.1108/JGR-10-2024-0197

[37] F. Jahan, S. Chowdhury, and M. Hoque, "The Effect of AI Adoption and Green Leadership on Organizational Environmental Performance in SMEs," *International Journal of Religion*, vol. 5, pp. 2207–2222, Jun. 2024, https://doi.org/10.61707/j9a56362

[38] Mishrif, Ashraf, and Asharul Khan. "Technology adoption as survival strategy for small and medium enterprises during COVID-19." *Journal of Innovation and Entrepreneurship* 12, no. 1 (2023): 1-23. https://doi.org/10.1186/s13731-023-00317-9

[39] Achieng, Mourine S., and Masike Malatji. "Digital transformation of small and medium enterprises in sub-Saharan Africa: A scoping review." *The Journal for Transdisciplinary Research in Southern Africa* 18, no. 1 (2022): 1257. https://hdl.handle.net/10520/ejc-transd_v18_n1_a1257

[40] Wylde, Vinden, Nisha Rawindaran, John Lawrence, Rushil Balasubramanian, Edmond Prakash, Ambikesh Jayal, Imtiaz Khan, Chaminda Hewage, and Jon Platts. "Cybersecurity, data privacy and blockchain: A review." *SN computer science* 3, no. 2 (2022): 127. https://doi.org/10.1007/s42979-022-01020-4

[41] Wen, Baodong, Yujue Wang, Yong Ding, Haibin Zheng, Bo Qin, and Changsong Yang. "Security and privacy protection technologies in securing blockchain applications." *Information Sciences* 645 (2023): 119322. https://doi.org/10.1016/j.ins.2023.119322

[42] Restrepo-Morales, Jorge Aníbal, Jaime Andrés Ararat-Herrera, Diego Alejandro López-Cadavid, and Aquileo Camacho-Vargas. "Breaking the digitalization barrier for SMEs: a fuzzy logic approach to overcoming challenges in business transformation." *Journal of Innovation and Entrepreneurship* 13, no. 1 (2024): 84. https://doi.org/10.1186/s13731-024-00429-w

[43] Shalhoob, Hebah, and Khaled Hussainey. "Environmental, social and governance (ESG) disclosure and the small and medium enterprises (SMEs) sustainability performance." *Sustainability* 15, no. 1 (2022): 200. https://doi.org/10.3390/su15010200

[44] Morris, Jonathan, Wyn Morris, and Robert Bowen. "Implications of the digital divide on rural SME resilience." *Journal of Rural Studies* 89 (2022): 369-377. https://doi.org/10.1016/j.jrurstud.2022.01.005

[45] Sagala, Gaffar Hafiz, and Dóra Őri. "Toward SMEs digital transformation success: a systematic literature review." *Information Systems and e-Business Management* 22, no. 4 (2024): 667-719. https://doi.org/10.1007/s10257-024-00682-2

[46] Ali, Rao Faizan, Hamid Jahankhani, Kashif Ali, and Bilal Hassan. "Blockchain-based security factors on sustainable supply chain management in UK manufacturing firms: A hybrid SEM-ANN approach." *Systems* 12, no. 6 (2024): 208. https://doi.org/10.3390/systems12060208

[47] Singh, Rajesh Kumar, Ruchi Mishra, Shivam Gupta, and Archana A. Mukherjee. "Blockchain applications for secured and resilient supply chains: A systematic literature review and future research agenda." *Computers & Industrial Engineering* 175 (2023): 108854. https://doi.org/10.1016/j.cie.2022.108854

[48] OECD (2025), "Fostering convergence in SME sustainability reporting", OECD SME and Entrepreneurship Papers, No. 66, OECD Publishing, Paris, https://doi.org/10.1787/ffbf16fb-en

[49] Harventy, Gina, Fatima Abdul Hamid, Fatimah Mat Yassin, and Norsyahida Binti Mokhtar. "Research trends on environmental, social, and governance in SMEs: A bibliometric analysis." *Journal of Accounting and Investment* 26, no. 1 (2025): 379-400. https://doi.org/10.18196/jai.v26i1.25808

[50] Kannan, Selvi, and Nicolás Gambetta. "Technology-driven sustainability in small and medium-sized enterprises: a systematic literature review." *Journal of Small Business Strategy* 35, no. 1 (2025): 129-157. https://doi.org/10.53703/001c.126636

[51] OECD (2021), Incentives for SMEs to Invest in Skills: Lessons from European Good Practices, Getting Skills Right, OECD Publishing, Paris, https://doi.org/10.1787/1eb16dc7-en

[52] Ali, Ehtesham, Habiba Ashraf, Syed Muzzamil Ali Shah, Muhammad Abdullah, Qadri Waseem, Muhammad Faizan, Muhammad Aleem, and Muhammad Adil. "Enabling Smart and Sustainable Solutions: Applications of Wireless Sensor Networks in the Era of IoT." *International Journal of Advanced Research in Computational Thinking and Data Science* 5, no. 1 (2025): 50-59. https://doi.org/10.37934/ctds.5.1.5059a

[53] Hammad, Muhammad Yahya, Syed Radzi Rahamaddulla, and Muhammad Ashraf Fauzi. "Environmental and governance strategies in ESG for industry 4.0: a systematic review." *AIMS Environmental Science* 12, no. 4 (2025): 557-575. https://doi.org/10.3934/environsci.2025025