

Blockchain and New Technologies for Enhanced Transparency in ESG Sustainability Reporting and Accounting



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ABSTRACT

This study investigates the role of blockchain and emerging digital technologies in enhancing the integrity, traceability, and accountability of ESG disclosures. The purpose of this research is to analyze how blockchain, supported by artificial intelligence, big data, and cloud computing, can transform traditional ESG reporting systems into more transparent and efficient mechanisms. Using a qualitative research approach with a descriptive method, this study reviews current literature, case studies, and practical implementations of blockchain in sustainability accounting. The findings reveal that blockchain technology offers real-time data recording, immutability, and decentralized verification, which significantly mitigate issues of greenwashing and fraudulent reporting. It is recommended that organizations begin piloting these technologies in specific ESG areas while governments and international bodies work toward unified regulatory guidelines. This research contributes to the academic discourse by offering a comprehensive framework for understanding the technological transformation of ESG accounting and highlights its implications for practitioners, policymakers, and future researchers.

1. INTRODUCTION

According to Donthu et al. (2021), in recent years, the global discourse on sustainability and corporate social responsibility has undergone significant

development, driven by growing awareness of the importance of Environmental, Social, and Governance (ESG) criteria. Companies across various industrial sectors are now facing increasingly complex demands to not only consider financial aspects, but also the impact of their operations on the environment and society. In response to these demands, ESG reporting has become an integral component of modern business strategies focused on sustainable development. However, the ESG reporting ecosystem still faces significant challenges related to the accuracy, transparency, and credibility of the reported data. In this context, according to Gurzhii et al. (2022), the ongoing digital revolution offers transformative opportunities to address the limitations of conventional sustainability accounting practices. Technologies such as blockchain, artificial intelligence (AI), the Internet of Things (IoT), and big data analytics have the potential to revolutionize how companies collect, validate, and report their ESG information. These disruptive technologies provide innovative solutions to enhance the integrity, transparency, and efficiency of an increasingly complex ESG reporting ecosystem.

According to Alidrisi (2021), blockchain, as a distributed ledger technology, possesses unique characteristics that are highly relevant to the needs of ESG reporting. Its immutable and transparent nature enables secure and verifiable recording of ESG data, thereby offering the potential to address issues such as greenwashing and data manipulation, which have long been concerns for many stakeholders. This technology allows for real-time tracking and verification of sustainability claims with a higher level of trust. According to Ahmed et al. (2022), artificial intelligence (AI) and machine learning, on the other hand, offer the capability to analyze massive volumes of ESG data with a level of accuracy and speed that is unattainable through conventional methods. These technologies help companies identify patterns, trends, and anomalies within their ESG data, thereby enhancing decision-making processes and strategic planning. The integration of IoT with ESG reporting systems also enables the automatic collection of data from various sensors and devices, reducing the risk of manual input errors and improving the granularity of the available data.

However, according to Mukhiyayeva (2024), the adoption of digital technologies in sustainability accounting also presents its own set of challenges. Technical complexity,

substantial investment requirements, interoperability issues, and various concerns related to data privacy and security constitute significant obstacles that need to be addressed. The standardization and harmonization of ESG reporting frameworks remain unresolved issues, despite important contributions from initiatives such as the Task Force on Climate-related Financial Disclosures (TCFD) and the standards developed by the International Sustainability Standards Board (ISSB). According Minggu et al. (2023), in Indonesia, the digital transformation of sustainability accounting holds particular relevance given the country's economic growth momentum and its national commitment to sustainable development. Since the issuance of the Financial Services Authority Regulation (POJK) Number 51/POJK.03/2017 on the Implementation of Sustainable Finance, public companies and financial service institutions have been required to publish sustainability reports. However, the effective implementation of this regulation still faces several obstacles, including limitations in digital infrastructure and technical capacity to adopt new technologies in ESG reporting.

According to Buckner et al (2016), in the era of digital disruption marked by the radical transformation of various business aspects, sustainability accounting systems must also adapt and harness the potential of new technologies to enhance the quality, transparency, and credibility of ESG reporting. The integration of blockchain and other digital technologies into ESG reporting infrastructure holds the potential to bridge the trust gap that has long been a major challenge in the sustainability accounting ecosystem. By reducing information asymmetry and improving data verifiability, digital transformation can strengthen the function of sustainability accounting as a tool for public accountability and a catalyst for a shift toward a more sustainable business paradigm. X. Liu et al (2020) state that innovations in financial technology (fintech) and regulatory technology (regtech) also offer new perspectives in the context of ESG reporting. Blockchain-based platforms that provide infrastructure for the tokenization of green assets and the issuance of green bonds demonstrate the tangible potential of digital technology integration in the sustainable finance ecosystem. The implementation of smart contracts can automate the verification of ESG target achievements and allocate incentives based on actual performance, thereby reinforcing accountability mechanisms within sustainability reporting systems.

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According to Dal Mas et al (2020), the digital transformation in sustainability accounting also carries significant implications for the accounting and auditing professions. New competencies related to understanding blockchain technology, data analytics, and digital information systems have become crucial for modern sustainability accounting practitioners. This evolution necessitates a reorientation of accounting education and professional development programs to accommodate a more interdisciplinary skill set, combining traditional accounting expertise with digital technology proficiency and a deep understanding of sustainability issues. Based on a comprehensive exploration of the context and urgency of digital transformation in sustainability accounting. Despite growing interest in digital technologies for ESG reporting, significant research gaps persist regarding the comprehensive integration of blockchain and other digital technologies into sustainability accounting systems (Tang & Zhang, 2022). Prior studies have predominantly focused on theoretical aspects or single technology implementations, neglecting holistic approaches that combine multiple digital technologies to enhance ESG reporting transparency and credibility. As noted by Pizzi et al. (2021), there is a notable scarcity of empirical research investigating blockchain's effectiveness in addressing specific issues like greenwashing and ESG data manipulation, particularly in emerging markets such as Indonesia. Knowledge gaps also exist in understanding the technical, regulatory, and institutional barriers affecting digital technology adoption in sustainability accounting across countries with varying digital infrastructure maturity (Vishnevskiy et al., 2023). Additionally, the impact of digital transformation on the sustainability accounting profession and the need for new competencies remains insufficiently explored. This research aims to address these gaps by providing a systematic and contextual analysis of digital technologies' transformative role in reforming sustainability accounting systems, especially in Indonesia's growing economy.

This study aims to systematically analyze the role of blockchain technology and other digital innovations in enhancing the transparency and credibility of ESG reporting. More specifically, this research seeks to: (1) identify the specific mechanisms through which blockchain and digital technologies can strengthen the integrity of ESG data; (2) evaluate the potential impact of digital technology adoption on the efficiency and effectiveness of

ESG reporting processes; (3) analyze the technical, regulatory, and institutional challenges in implementing digital solutions for sustainability accounting; and (4) formulate strategic recommendations to accelerate the adoption of digital technologies in the ESG reporting ecosystem, taking into account the specific context of Indonesia and global developments. Through this study, it is expected that a more comprehensive understanding will emerge regarding the transformative potential of digital technologies in reforming sustainability accounting systems and enhancing the credibility of ESG reporting in the digital economy era.

2. LITERATURE REVIEW AND HYPOTHESIS

Institutional Theory

According to Bonzanini et al. (2020), institutional theory provides a crucial framework for understanding how the adoption of digital technologies in Environmental, Social, and Governance (ESG) reporting is influenced by institutional pressures and the pursuit of legitimacy. This theory posits that organizations are driven not only by technical efficiency but also by the need to conform to norms, rules, and expectations embedded in their business environment. In the context of digital transformation for ESG reporting, institutional theory outlines three mechanisms of institutional pressure that influence technology adoption: coercive, normative, and mimetic. Coercive pressures arise from regulations and legal frameworks that mandate more transparent and verifiable ESG reporting. As identified by Seretakakis & Mezzanotte (2023), the regulatory framework for blockchain in sustainable reporting within the European Union is still evolving and requires harmonization, thereby creating coercive pressure for organizations to adapt to continuously developing standards. Normative pressures stem from professional expectations and industry standards. Al-sanasleh et al. (2025) highlight institutional challenges such as competency gaps among audit committees and stakeholders in understanding new technologies for ESG reporting. This reflects an evolution of professional norms that demand new competencies in digital technologies and ESG. Meanwhile, mimetic pressures occur when organizations imitate the practices of other organizations perceived as successful or legitimate. According to Fristamara (2025), there is a growing emphasis on repositioning ESG not Blockchain and New Technologies for Enhanced Transparency in ESG Sustainability Reporting and Accounting

merely as a matter of compliance but as a profitable business strategy, prompting companies to emulate best practices in the implementation of digital technologies for ESG reporting.

Institutional theory also explains the phenomenon of decoupling, where organizations may formally adopt institutionally legitimized practices—such as blockchain technology for ESG reporting—yet the actual implementation may be limited or largely symbolic. Arifin (2024) identifies credibility challenges in the form of investor skepticism toward sustainability reports, which can be attributed to the gap between formal adoption and the substantive implementation of digital technologies in ESG reporting. The integration of institutional theory with the adoption of digital technologies in ESG reporting highlights that effective digital transformation requires changes not only in technological infrastructure but also in institutional norms, values, and practices. As recommended by Kristianto et al. (2025), updates to accounting education curricula and professional development programs focused on digital technologies in the ESG context are necessary to institutionalize new competencies within the accounting profession.

The Evolution of ESG Reporting and Challenges in Sustainability Accounting

According to Pizzi et al. (2020), Environmental, Social, and Governance (ESG) reporting has undergone significant evolution over the past two decades. Initially voluntary and unstandardized, ESG reporting has now developed into an integral component of corporate communication and sustainable business strategy. With growing attention to climate change and social inequality, investors and other stakeholders are demanding greater transparency regarding companies' impacts on society and the environment. In response, various standards and frameworks have been developed—including the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), and Task Force on Climate-related Financial Disclosures (TCFD)—which have helped shape contemporary ESG reporting practices. Despite increasing standardization, sustainability accounting continues to face fundamental challenges. Pizzi et al. (2020) also identify the lack of comparability between reports and the difficulty in establishing relevant metrics across different industries as major

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barriers. The failure to meaningfully integrate non-financial information into business decision-making further limits the transformative potential of ESG reporting. La Torre et al. (2018) highlight the phenomenon of greenwashing where companies present a more sustainable public image than their actual practices which has undermined the credibility of ESG reporting and made it more difficult for stakeholders to assess true sustainability performance.

In Indonesia, the implementation of ESG reporting faces specific challenges. Although the Financial Services Authority (OJK) has issued regulations requiring publicly listed companies to publish sustainability reports, there remains a significant implementation gap. Lehenchuk et al. (2023) identify key obstacles including a lack of internal expertise, high implementation costs, and difficulties in collecting relevant data. This implementation gap is especially evident among small and medium-sized enterprises, which often lack the resources to adopt comprehensive ESG reporting practices. The continually evolving standards for sustainability reporting present an additional challenge for Indonesian companies. The transition from PSAK 1 to more comprehensive sustainability reporting standards requires substantial investment in capacity building and reporting infrastructure. Moreover, according to Lehenchuk et al. (2023), the misalignment between international standards and the local regulatory context adds further complexity for companies operating in global markets. To bridge this gap, a more integrated approach is needed one that involves collaboration between regulators, academics, and industry practitioners.

Recent research by Nurunnabi et al. (2019) reveals that the quality of ESG disclosure in Indonesia still varies significantly, with the financial and mining sectors demonstrating higher levels of compliance compared to other industries. This reflects the influence of regulatory pressure and international investor expectations on reporting practices. The study also highlights the importance of strong corporate governance in promoting high-quality ESG disclosure, showing that companies with better governance structures are more likely to produce comprehensive ESG reports. Recent developments in global standard harmonization, such as the establishment of the International Sustainability Standards Board (ISSB) in 2021, present opportunities to address some of

these challenges. Greater standardization has the potential to enhance comparability and reduce the reporting burden on Indonesian firms. However, transitioning to harmonized standards will require coordinated efforts from all stakeholders and may necessitate investments in digital technologies to automate and streamline the reporting process.

Blockchain Technology as the Foundation of Digital Transformation in Sustainability Accounting

Blockchain offers transformative solutions to the challenges faced in sustainability accounting, particularly in terms of transparency, verification, and trust. The inherent characteristics of blockchain—decentralization, immutability, and transparency—create an ideal foundation for enhancing the credibility of ESG reporting. According to Li et al. (2021), through immutable record-keeping, blockchain can prevent data manipulation and provide a comprehensive audit trail, thereby increasing stakeholder trust in reported ESG information. In the ESG context, blockchain can be implemented through various typologies. Permissionless blockchains enable open access and maximum transparency, while permissioned blockchains offer greater control over who can verify transactions—striking a balance between transparency and privacy tailored to the specific needs of an organization. Li et al. (2021) also highlight consortium blockchains, where multiple entities collaborate to validate transactions. This model emerges as a promising approach for industry-specific ESG reporting, allowing for standardization and cross-verification within a sector.

Concrete applications of blockchain in sustainability accounting are beginning to emerge. In supply chain tracking, for instance, blockchain enables real-time monitoring of product origins and verification of sustainability claims. According to Dal Mas et al. (2020), in the energy sector, blockchain-based platforms facilitate the trading of verified carbon credits, reducing the risk of double counting and enhancing the integrity of carbon markets. In Indonesia, pilot projects have begun exploring the use of blockchain to verify sustainable agricultural practices and manage certifications for environmentally friendly products. The potential integration of smart contracts with ESG reporting represents a significant advancement. Smart contracts—computer protocols that automatically execute, verify, or enforce contract negotiations—can

automate ESG claim verification and link sustainability performance to real financial consequences. For example, according to Li et al. (2021), smart contracts can facilitate sustainability-linked bonds, where interest rates are automatically adjusted based on the achievement of verifiable ESG targets.

Dal Mas et al. (2020) identified that the implementation of blockchain in sustainability reporting can significantly reduce information asymmetry between companies and stakeholders. By enabling efficient and transparent third-party verification, blockchain creates a trust-based ecosystem that diminishes incentives for greenwashing and enhances accountability. Their case studies demonstrate how blockchain-based carbon emission tracking allows for real-time verification and reporting of emission reductions, thereby improving the effectiveness of climate mitigation initiatives. Kismawadi (2024) further highlights blockchain's potential to bridge the gap between companies and auditors in ESG data verification. Through the implementation of predetermined blockchain systems, auditors can access immutable ESG data, significantly reducing the time and cost required for verification. This model is particularly relevant in Indonesia, where auditing capacity for sustainability information remains limited, and it can help build the infrastructure necessary to scale up ESG reporting practices. However, the use of blockchain in sustainability accounting also presents unique challenges. The high energy consumption associated with some blockchain protocols raises concerns about the environmental impact of the technology itself—an ironic issue given its sustainability objectives. Kismawadi (2024) also points to more energy-efficient alternatives such as Proof-of-Stake (PoS) and layer-2 solutions as promising, although these still require further testing in the context of large-scale ESG applications.

Digital Technology Synergy in Integrated ESG Reporting Ecosystem

While blockchain offers effective solutions to several challenges in ESG reporting, its full potential can be realized when integrated with other digital technologies. According to Sedlmeir et al. (2020), combining blockchain with the Internet of Things (IoT), artificial intelligence (AI), and big data analytics can create a holistic ESG reporting ecosystem. IoT enables real-time data collection through sensors and

connected devices, significantly narrowing the gap between operational realities and reported data. When IoT-generated data is recorded on the blockchain, it establishes a verifiable "source-to-report" information stream that substantially enhances the credibility of ESG disclosures. AI and machine learning play a critical role in processing the vast volumes of ESG data collected from various channels. AI algorithms can identify patterns, detect anomalies, and automate verification processes that previously required extensive manual intervention. Sedlmeir et al. (2020) also highlight AI's capacity to interpret data and generate meaningful insights, aiding companies and stakeholders in understanding the implications of their ESG performance. In Indonesia, where ESG analytics expertise remains limited, AI-powered tools can help bridge the capacity gap and improve the quality of sustainability assessments.

According to Nurunnabi et al. (2019), the integration of big data analytics enables the processing and interpretation of complex and diverse ESG datasets. Through advanced analytical techniques, organizations can identify correlations between ESG indicators and financial performance, thereby informing business strategies and enhancing the quality of decision-making. Sedlmeir et al. (2020) emphasize that this integration is particularly relevant in the Indonesian context, where companies often struggle to assess the materiality of various ESG indicators and to prioritize areas for improvement. Crucially, the synergy between blockchain, IoT, AI, and big data creates a self-reinforcing cycle. Data collected via IoT devices is securely stored on blockchain networks, analyzed using AI algorithms, and interpreted through big data analytics to produce actionable insights. These insights can then inform modifications to data collection practices and improvements to AI algorithms, fostering a continuous improvement cycle in the quality of ESG reporting.

Research by Prawitasari et al. (2025) illustrates how this integrated ecosystem can specifically address challenges in verifying companies' "net-zero" claims. By combining IoT sensor data for emissions monitoring with blockchain-based verification and AI predictive analytics, organizations can provide stronger evidence of their progress toward decarbonization goals. This model also supports the development of more

efficient carbon markets by enhancing transparency and trust in carbon offset transactions. For developing countries like Indonesia, this integrated digital ecosystem presents valuable opportunities for "leapfrogging" the transitional phase in the evolution of ESG reporting. Compared to building extensive traditional reporting infrastructure, investing in integrated digital solutions provides a more efficient pathway toward comprehensive and reliable ESG reporting. According to Prawitasari et al. (2025), through this approach, Indonesian companies can overcome challenges related to limited expertise and underdeveloped data infrastructure, positioning themselves competitively in a global market increasingly focused on sustainable business practices. Sedlmeir et al. (2020) also highlight the critical role of open and standardized data models in facilitating interoperability across the ESG reporting ecosystem. By adopting open standards for data exchange and consistent ESG taxonomies, technology-based reporting systems can create a "common language" for sustainability information, significantly improving the comparability and usefulness of ESG disclosures. This standardization is especially important in Indonesia, given the diversity of its industrial sectors and varying levels of sophistication in reporting practices.

Implementation Challenges and Adoption Framework for Digital Technologies in Sustainability Accounting

According to Kiviat (2022), despite its significant transformative potential, the implementation of digital technology in sustainability accounting faces several challenges that need to be addressed. From a technical perspective, scalability and interoperability limitations are major obstacles. Certain blockchain protocols face constraints in transaction processing speed, which may limit their application in the context of large ESG datasets. Furthermore, Kismawadi (2024) highlights that the lack of standardization across blockchain platforms presents interoperability challenges, making it difficult for companies to exchange ESG data across systems or integrate with existing infrastructure. Organizational challenges are also significant. The implementation of digital technology for ESG reporting requires a level of technical expertise that is still limited in many organizations in Indonesia, especially in small and medium-sized enterprises. Resistance to change among traditional accounting personnel

and a lack of understanding about the potential of blockchain technology can also hinder adoption. The shift from traditional reporting models, which are well-established, to a digital-based system requires not only technological investment but also a significant cultural and organizational transformation. The evolving regulatory landscape adds additional complexity. In Indonesia, the regulatory framework for ESG reporting is still in development, with the Financial Services Authority (OJK) continually refining requirements for public companies. This regulatory uncertainty may cause companies to hesitate in investing in new technological solutions, fearing that these systems may not align with future requirements. Additionally, questions about data governance, including who controls and owns ESG data on blockchain-based platforms, require regulatory clarity before large-scale implementation can take place.

Kiviat (2022) also suggests that economic barriers also shape adoption decisions. The initial costs associated with implementing blockchain-based solutions and other digital technologies can be a significant obstacle, especially for small and medium-sized enterprises (SMEs) with limited resources. While the long-term benefits may be substantial, including reduced audit costs and improved reporting efficiency, the lack of proven business cases and the long payback period may hinder investment decisions. To overcome these challenges, an adaptive adoption framework that takes into account the specific context of Indonesia is needed. Kiviat (2022) proposes a phased approach that allows organizations to begin with a limited implementation, focusing on the most material ESG areas for their operations. This approach allows companies to gradually build internal expertise and demonstrate the value of the technology before undertaking more comprehensive implementation. Multi-stakeholder collaboration is also a key component of a successful adoption framework. Kismawadi (2024) emphasizes the importance of partnerships between companies, regulators, educational institutions, and technology providers in creating a supportive ecosystem for digital transformation in sustainability accounting. Industry consortia and knowledge-sharing platforms can help bridge expertise gaps and reduce implementation costs by developing shared standards and open-source solutions.

Systematic capacity building is also a key element of a successful adoption framework. Targeted training programs for accounting and sustainability professionals, the integration of digital technology into university accounting curricula, and the development of specialized certifications for digital sustainability accounting can help create the workforce needed to support the transformation. From a regulatory perspective, a "regulatory sandbox" approach, which allows experimentation with digital solutions in a controlled environment, can bridge the gap between technological innovation and regulatory development. Kismawadi (2024) demonstrates how such frameworks can allow regulators and companies to jointly identify challenges and develop guidelines that reflect the realities of practical implementation. Finally, emphasizing the development of solutions that consider Indonesia's local context is crucial. Compared to directly adopting international platforms, adapting technology to meet the specific needs and challenges of the Indonesian market is likely to result in higher adoption rates and more successful implementation. This includes considering available digital infrastructure, existing business practices, and cultural preferences in the design of digital solutions for sustainability accounting.

Previous Research

This study employs a Systematic Literature Review (SLR) adhering to the PRISMA protocol to ensure methodological rigor. We conducted a comprehensive search across Scopus, Garuda, SINTA, ResearchGate, and Google Scholar using keywords including "blockchain," "digital transformation," "ESG reporting," "sustainability accounting," "transparency," and "credibility." Articles were systematically filtered through a three-stage process: initial identification (n=87), screening based on titles and abstracts against inclusion criteria (n=59), and full-text assessment for relevance (n=30). Selected papers were analyzed using content analysis techniques to identify technological applications, implementation frameworks, challenges, and outcomes specific to blockchain's role in enhancing ESG reporting transparency and credibility.

Table 1. Inclusion and Exclusion Criteria Publication

Criteria	Inclusion	Exclusion
Type of Publication	Peer-reviewed journal articles, academic books, and conference proceedings	Non-academic articles (e.g., blogs, news), undergraduate theses, internal company documents
Publication Year	Published between 2018 and 2025	Published before 2018
Research Topic	Focused on blockchain, digital transformation, emerging technologies, and sustainability accounting (ESG)	Unrelated to ESG, sustainability accounting, or digital transformation
Journal Indexing	Indexed in Scopus (Q1–Q4), SINTA (1–6), or verified with valid E-ISSN (e.g., through Google Scholar)	Not indexed in Scopus or SINTA; lacking valid E-ISSN or unverifiable academic credibility
Content Availability	Full-text available; consistent and coherent between title, abstract, and main content	Abstract only; full-text unavailable; or discrepancies between abstract and article content
Language	Articles written in English or Indonesian	Articles written in languages other than English or Indonesian

The writing of this paper begins by collecting various articles from national and international journals such as SINTA, Scopus, ResearchGate, Garuda, and Google Scholar, totaling 87 articles. From this, 30 relevant articles were identified and selected to be included in the previous research, which consist of:

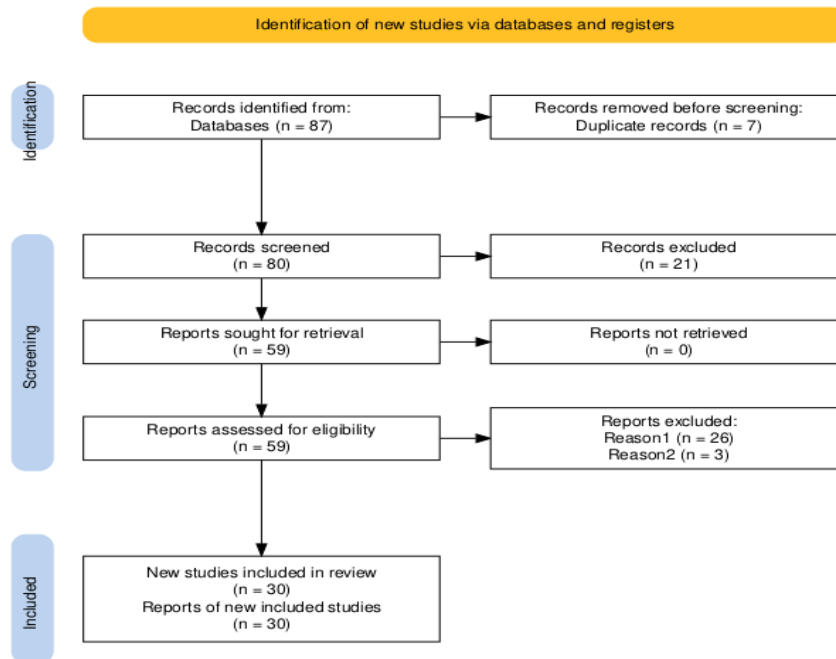
Table 2. Table of Previous Research Source

Source of Article	Number
Registered E-ISSN Journals - Environmental and Social Governance Journal diakses dari google scholar, Garuda, index Copernicus, scilit, corssref.	2
Scopus Q1 - Journal of Business Research - Journal of Cleaner Production - Accounting, Auditing & Accountability Journal - IEEE Transactions on Sustainable Computing - Sustainability Accounting, Management and Policy Journal	11

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Scopus Q2 - IT Professional - Logistics	4
Scopus Q3 - Journal of Financial Studies - Corporate Sustainability Review - Asian Journal of Sustainability Studies	5
Scopus Q4 - International Journal of Accounting	2
SINTA 2 - Jurnal Akuntansi dan Auditing Indonesia	2
SINTA 3 - Emerging Markets Finance & Trade	2
SINTA 4 - Global Business & Finance Review	2
TOTAL	30

The selection, screening, and collection of previous research articles were assisted by the PRISMA flow diagram website to obtain data related to this topic based on the predetermined criteria.



Picture 1. PRISMA Flow Diagram

Based on the analysis of previous articles, the author formulates a conclusion regarding the connection between Blockchain and New Technologies, which can Enhance the Transparency and Credibility of ESG Reporting. The table below presents a summary of the selected previous studies that are used as the main references in this research.

Table 3. Previous Research Related to the Relationship Between Blockchain and New Technologies in Enhancing Transparency and Credibility of ESG Reporting - Research Methods

Authors	Findings
(Dudek & Kulej-Dudek, 2024), (L. Liu et al., 2024), (Hidayati et al., 2024), (Arifin, 2024), (Nurita et al., 2025), (Salma, 2025), (Bengu & Bangsa, 2024), (Choi & Purpose, 2025), (Sisdianto et al., 2024), (Putri & Harry, 2025), (Pasaribu & Soeratin, 2024), (Silvera et al., 2024), (Pappa et al., 2024), (Asiva Noor Rachmayani, 2015), (Almadadha, 2024), (Fristamara, 2025), (Fadilla et al., 2025), (Rerung, 2024), (Wiputra et al., 2024), (Halim et al., 2025), (Bhandari et al., 2025), (Kristianto et al., 2025), (Hajiyev, 2024), (Salehi, 2023), (Saxena et al., 2023), (Alotaibi et al., 2024), (Omowonuola Ireoluwapo Kehinde Olanrewaju, 2024), (Rusman, 2024), (Laskari, 2025), (Salim et al. (2025)	+
	(-)
(+) positive impact, (-) negative impact	

3. RESEARCH METHOD

This research employs a systematic literature review (SLR) method with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to analyze the digital transformation in sustainability accounting. The research process begins with the identification of keywords related to blockchain, digital technologies, ESG, and sustainability accounting in indexed scientific databases such as Scopus, Web of Science, SINTA, and Google Scholar. Inclusion criteria include articles in both English and Indonesian published between 2018-2025, focusing on blockchain and digital technologies in ESG reporting. The screening stage involves reviewing titles and abstracts against the inclusion and exclusion criteria, followed by a full-text assessment to determine article suitability. Out of 87 identified articles, 37 are considered relevant, and 30 articles meet the criteria for in-depth analysis. The

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distribution of the articles includes 22 from Scopus-indexed journals (Q1-Q4) and 8 from national journals indexed in SINTA (2-4). The data extraction method utilizes a synthesis table with parameters such as publication year, methodology, main contributions, and practical implications. The analysis is conducted thematically to identify patterns, trends, and gaps in the literature related to the implementation of blockchain and digital technologies in enhancing the transparency and credibility of ESG reporting.

4. RESULTS AND DISCUSSIONS

Specific Mechanisms of Blockchain and Digital Technologies in Strengthening ESG Data Integrity

Blockchain has emerged as a transformative technology capable of addressing various data integrity challenges in Environmental, Social, and Governance (ESG) reporting. L. Liu et al. (2024) developed a solution called "Veri-Green," which implements a blockchain-based incentive model to enhance trust in ESG verification. Through the Vickrey-Clarke-Groves (VCG) mechanism, this solution offers a decentralized approach that significantly boosts the credibility of ESG data. In line with this, Choi & Purpose (2025) demonstrated the implementation of a Hyperledger Fabric-based platform that integrates Non-Fungible Token (NFT) technology to ensure the provenance and authentication of ESG data, preventing manipulation. Salehi (2023) emphasizes that blockchain technology provides a comprehensive solution to data integrity issues in ESG reporting through three main mechanisms: immutability, transparency, and traceability. Immutability ensures that once data is stored, it cannot be retrospectively altered; transparency allows all stakeholders to verify the information; while traceability facilitates tracking the data source back to its origin. Pappa et al. (2024) added that the implementation of blockchain in ESG auditing substantially enhances the reliability of reports by creating an audit system resistant to manipulation.

In the context of supply chain sustainability, Alotaibi et al. (2024) demonstrate how blockchain supports more accurate carbon accountability through an immutable tracking system. This system allows organizations to monitor and verify sustainability claims
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across the supply chain with a high level of trust. Wiputra et al. (2024) take this a step further by designing a blockchain-based ESG rating mechanism that significantly enhances the credibility and consistency of ESG assessments. In addition to blockchain, Artificial Intelligence (AI) and big data technologies also play a crucial role in strengthening the integrity of ESG data. Fadilla et al. (2025) show that AI algorithms can significantly improve the accuracy and consistency of ESG audits compared to traditional methods. AI can identify data anomalies and inconsistencies that may go undetected by human auditors. Omowonuola Ireoluwapo Kehinde Olanrewaju (2024) also emphasizes how big data analytics can revolutionize ESG reporting in clean energy initiatives through its ability to integrate and analyze large volumes of data from various sources. Halim et al. (2025) identify the implementation of Audit 4.0 technology, which integrates AI and satellite imagery to enhance the accuracy of ESG assurance. The integration of these technologies creates a comprehensive data verification ecosystem, fundamentally changing the way organizations monitor, measure, and report their sustainability performance.

Potential Impact of Digital Technology Adoption on the Efficiency and Effectiveness of ESG Reporting Processes

The adoption of digital technology in ESG reporting brings transformative impacts on operational efficiency and effectiveness. Dudek & Kulej-Dudek (2024), through a case study in a Polish company, demonstrate that the implementation of modern technologies significantly enhances transparency and operational efficiency, while helping the company meet increasingly stringent global reporting standards. This finding is supported by Putri & Harry (2025), who identify that the integration of ESG with digital transformation positively correlates with improved operational efficiency and financial performance. Almadadha (2024) shows that the implementation of blockchain in financial and ESG accounting not only improves data transparency but also substantially reduces verification costs and audit time. This technology enables real-time verification and automatic consistency checks of data, eliminating the need for time-consuming manual processes prone to errors. Bhandari et al. (2025) further strengthen this argument by demonstrating how blockchain can dramatically enhance efficiency in sustainable finance through automation of verification

and transaction tracking.

In the context of auditing, Salim et al. (2025) demonstrate that Robotic Process Automation (RPA) significantly enhances the efficiency and accuracy of ESG audits through the automation of repetitive tasks and the standardization of processes. The implementation of RPA allows audit teams to focus their efforts on high-value analysis and interpretation of results, rather than data collection and processing. Fadilla et al. (2025) add that AI not only improves audit accuracy but also dramatically reduces the time required to complete comprehensive ESG audits. Nurita et al. (2025) emphasize that integrating environmental accounting with digital technologies in ESG reporting leads to significant improvements in transparency and the accuracy of environmental data. Technologies such as the Internet of Things (IoT) and smart sensors enable real-time data collection on sustainability aspects, such as carbon emissions and resource usage, which were previously difficult to measure accurately. Saxena et al. (2023) identify how Industry 4.0 technologies, including IoT, AI, and blockchain, fundamentally enhance the quality and comprehensiveness of ESG reporting. Rerung (2024) shows that fintech and blockchain innovations significantly improve financial transparency in companies, which in turn strengthens the quality of ESG reporting. Laskari (2025) extends this discussion by highlighting that sustainability reporting supported by digital technologies plays a crucial role in achieving net-zero emissions targets, through its ability to accurately track and verify carbon reduction initiatives.

Technical, Regulatory and Institutional Challenges in Implementing Digital Solutions for Sustainability Accounting

Despite the promising transformative potential of digital technologies in sustainability accounting, their implementation faces various complex challenges. Hajiyeve, (2024) identifies that the regulatory framework for blockchain in sustainability reporting within the European Union is still under development and requires harmonization to avoid fragmentation and legal uncertainty. These regulatory challenges reflect broader difficulties in regulating rapidly evolving technologies in a relatively new sector. From a technical perspective, Choi & Purpose (2025) highlight the complexities involved in designing and implementing blockchain platforms that can

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accommodate the frequently changing standards and metrics of ESG. This challenge is compounded by the heterogeneity of ESG data and the lack of standardization in measurement and reporting methods. Wiputra et al. (2024) further add that interoperability between various blockchain systems and conventional reporting platforms remains a significant challenge that requires innovative technical solutions.

Pasaribu & Soeratin (2024) highlight institutional challenges in the form of a competency gap between audit committees and other stakeholders in understanding and utilizing new technologies for ESG reporting. Kristianto et al. (2025) strengthen this view by emphasizing that professional accountants need to master AI, big data, and blockchain to remain relevant in the digital era, indicating the need for a competency transformation across the accounting profession. Institutional challenges also arise in the form of resistance to change. Salim et al. (2025) identify that the implementation of RPA in ESG audits often faces resistance due to concerns about workforce reduction and changes in established workflows. Additionally, L. Liu et al. (2024) point out that designing appropriate incentive mechanisms for incentive-based blockchain systems remains a challenge, as it requires balancing participation incentives with the prevention of manipulation.

Almadadha, (2024) emphasizes that significant upfront investments are required to implement blockchain solutions in financial accounting and ESG, which can be a barrier to adoption, especially for small and medium-sized enterprises. This challenge is compounded by the high energy consumption of some blockchain platforms, which ironically may contradict the sustainability goals they aim to achieve. Arifin (2024) identifies credibility challenges in the form of investor skepticism towards sustainability reports, highlighting the importance of not only implementing new technologies but also building trust in their usage. Silvera et al. (2024) add an ethical dimension by stating that good governance and strong corporate social responsibility are essential to ensure that digital technologies are used responsibly in ESG reporting.

Strategic Recommendations for Accelerating Digital Technology Adoption in the ESG Reporting Ecosystem

Based on a comprehensive review of the literature, several strategic

recommendations can be formulated to accelerate the adoption of digital technology in the ESG reporting ecosystem, considering the Indonesian context and global developments. First, Bengu & Bangsa (2024) propose integrating financial innovations such as carbon derivatives and green bonds to accelerate the development of carbon markets in Indonesia, which could drive the adoption of digital technology for verification and reporting. Hidayati et al. (2024) recommend a comprehensive financial innovation strategy to support the transition to a green economy, with a specific focus on leveraging digital technologies to enhance transparency and efficiency in sustainable finance. According to Junanda (2024), this strategy includes the development of innovative financial products that are intrinsically linked to digitally verified ESG metrics, as implemented by PT Adaro Energy Indonesia.

Rusman (2024) advocates for a phased approach in the implementation of digital accounting systems for MSMEs, which could serve as a model for broader adoption of ESG reporting technologies in small and medium-sized enterprises in Indonesia. This approach recognizes the resource limitations and capacity of MSMEs while preparing them for stricter sustainability reporting standards in the future. To address competency challenges, Kristianto et al. (2025) recommend updating accounting curricula and ongoing professional development programs for accountants, focusing on digital technologies in the context of ESG. This recommendation includes integrating training on AI, blockchain, and big data analytics into core curricula, as well as offering specialized certification programs in digital sustainability accounting. Halim et al. (2025) propose the development of an integrated Audit 4.0 infrastructure for ESG, combining big data analytics with the Global Reporting Initiative (GRI) reporting framework. This approach would facilitate standardization and interoperability in the ESG reporting ecosystem while leveraging advanced analytics capabilities to improve audit quality.

Fristamara (2025) emphasizes the importance of repositioning ESG not only as compliance but also as a profitable business strategy. This recommendation acknowledges that in order to drive the adoption of digital technology in ESG reporting, companies need to view the long-term business value of their investments, not just as a cost of compliance. Pasaribu & Soeratin (2024) advocate for strengthening the role of

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audit committees in overseeing the quality of ESG reporting, with a specific focus on understanding and evaluating the implementation of digital technologies. This recommendation recognizes the crucial role of governance in ensuring the integrity and effectiveness of digital solutions for sustainable accounting. Finally, Hajiye (2024) recommends the development of an adaptive regulatory framework for blockchain technology in sustainability reporting, which can accommodate innovation while ensuring adequate protection against risks. This regulatory approach is particularly relevant in the context of Indonesia, where the legal framework for new technologies in financial and sustainability reporting is still evolving. Overall, accelerating the adoption of digital technologies in ESG reporting in Indonesia requires a multi-stakeholder approach that integrates technological innovation, capacity development, regulatory reform, and market transformation. By adopting this holistic approach, Indonesia can harness the transformative potential of digital technologies to strengthen its sustainable accounting system and enhance the credibility of ESG reporting in the rapidly developing digital economy.

5. CONCLUSIONS

This systematic literature review reveals that blockchain and digital technologies significantly enhance ESG reporting through specific mechanisms that strengthen data integrity, improve operational efficiency, and build stakeholder trust. Blockchain's immutability, transparency, and traceability features address fundamental challenges in sustainability accounting, while innovations like Veri-Green and Hyperledger Fabric platforms with NFT integration prevent data manipulation. The integration of AI, IoT, and big data analytics further improves audit accuracy and enables real-time environmental data collection. Despite these benefits, implementation faces technical challenges including interoperability issues and evolving standards; regulatory hurdles with underdeveloped frameworks; and institutional barriers including competency gaps among accountants and audit committees. To accelerate adoption, particularly in Indonesia, key recommendations include: integrating financial innovations like carbon derivatives with digital verification; implementing phased approaches for MSMEs; updating accounting education to include

digital competencies; developing integrated Audit 4.0 infrastructures aligned with GRI standards; repositioning ESG as a value-creating business strategy; strengthening audit committee oversight of digital implementations; and creating adaptive regulatory frameworks. A multi-stakeholder approach combining technological innovation, capacity development, regulatory reform, and market transformation is essential to fully leverage digital technologies for enhanced ESG reporting credibility.

IMPLICATIONS, LIMITATIONS AND SUGGESTIONS

Implications

1. Theoretical Implications

This study reinforces institutional theory by highlighting how coercive, normative, and mimetic pressures influence digital technology adoption in ESG reporting. It contributes to the literature by positioning blockchain and AI as tools that strengthen organizational legitimacy and reshape sustainability accounting frameworks.

2. Practical Implications

Practically, the study informs policymakers, companies, and practitioners about the strategic role of digital technologies in improving ESG data integrity and efficiency. It underscores the need for digital infrastructure, regulatory clarity, and professional training to support successful implementation, particularly in developing economies like Indonesia.

Suggestion

Based on some of the research conclusions that have been presented above, there are several suggestions from researchers for further research:

1. Quantitative Assessment of ESG Reporting Effectiveness

Further empirical research using quantitative methods is needed to measure how digital technologies impact the accuracy, timeliness, and cost-efficiency of ESG reporting. This includes conducting comparative studies across sectors or between companies that have and have not adopted digital ESG systems.

2. Governance Mechanisms and Digital Transformation

Future research should examine the role of audit committees, boards of directors, and internal control systems in overseeing and supporting digital ESG reporting implementation.

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Investigating the interaction between governance quality and technology effectiveness will help ensure accountability and mitigate risks of greenwashing or system manipulation.

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