Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AP06.20250089
Published: August 5, 2025

Blockchain Technology Implementation for Transparency, Traceability, and Supply Chain Sustainability: A Critical Viewpoint

Mahasena Jonatan
Department of Industrial Engineering
University of Surabaya
Surabaya, Indonesia
mahasenajonatan@gmail.com; s164124502@student.ubaya.ac.id

Markus Hartono
Department of Industrial Engineering
University of Surabaya
Surabaya, Indonesia
markus@staff.ubaya.ac.id

Abstract

Transparency, traceability, and sustainability have emerged as critical pillars in addressing the growing complexity of global supply chains. With its decentralized and immutable ledger system, blockchain technology offers a promising solution to these challenges. This study presents a systematic literature review of sixteen (16) peer-reviewed journals using the PRISMA methodology to examine the potential benefits of blockchain implementation within supply chain systems. The findings reveal that current applications largely emphasize technical efficiency, while aspects such as regulatory compliance, social impact, and relevance to developing countries remain underexplored. This study highlights the importance of an interdisciplinary approach that integrates technical, social, and regulatory perspectives. It also identifies an opportunity to develop comprehensive evaluation frameworks aligned with global sustainability indicators such as the SDGs and ESG, paving the way for more inclusive and responsible supply chain systems.

Keywords
Blockchain, Supply Chain, Transparency, Traceability, Sustainability

1. Introduction
The growing complexity of global supply chains demands greater levels of transparency and accountability. A lack of openness, limited traceability, and unsustainable practices in traditional systems have become persistent challenges (Osato Itohan Oriekhoe et al., 2024). Although the early adoption of blockchain technology was considered risky and costly, it is now widely seen as a promising solution for global supply chain management (Dede et al., 2021). Integrating this technology into supply chains has the potential to enhance cost efficiency, sustainability, transparency, traceability, and trust (Mahyuni et al., 2020).

Blockchain is believed to foster trust and transparency in decision-making processes by enabling transaction verification through an immutable, distributed ledger system (Mahapatra et al., 2021). Its role in supply chain systems is particularly relevant for addressing the erosion of trust in both second- and third-party stakeholders (Kshetri, 2022). Moreover, blockchain's value lies in its ability to meet consumer demands for quality, safety, reliability, transparency,

and ease of traceability (Tayal et al., 2021). These features are especially vital for managing supply chain networks that span across countries and industries. As a result, blockchain contributes significantly to ensuring the long-term sustainability of global supply chains.

1.1 Objective

The primary objective of this study is to systematically examine the role of blockchain technology in enhancing transparency, traceability, and sustainability within supply chain systems. By applying the PRISMA methodology, this research aims to develop a comprehensive understanding of how blockchain has been implemented across various industrial sectors and to assess its effectiveness compared to traditional approaches. In addition, this study seeks to identify research gaps in existing literature, particularly the lack of attention to social dimensions, regulatory frameworks, and applications in developing countries. Through a critical review of sixteen peer-reviewed journal articles, this research aims to propose recommendations for future investigations and highlight the need to develop evaluation frameworks that align with global sustainability indicators such as the Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) standards.

2. Literature Review

The literature review process in this study was conducted systematically by adopting the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The initial step involved identifying approximately 500 articles retrieved through the Elicit platform, using the keyword combinations "Blockchain," "Supply Chain," "Transparency," and "Traceability." However, not all of these articles were directly relevant or aligned with the specific focus of this research.

To ensure relevance and maintain the quality of the review, a careful and layered filtering process was applied. Articles were selected based on several key criteria: they had to explicitly discuss the implementation of blockchain in supply chain systems, particularly in relation to transparency, traceability, and sustainability aspects, while also offering comparative analysis with conventional systems. Only peer-reviewed journal articles written in English and with a minimum of ten (10) citations were considered, as an indicator of academic recognition and publication quality.

This filtering was not limited to title and abstract screening alone. Each shortlisted article underwent a thorough full-text review to confirm its relevance and alignment with the research objectives. Narrowing down to sixteen (16) core journal articles was by no means a straightforward task. Literature specifically addressing blockchain implementation with an integrated focus on transparency, traceability, and supply chain sustainability remains relatively limited. Many publications discuss blockchain from a general technological perspective without directly connecting it to supply chain contexts, or they focus on only one of the three aspects rather than all three in a comprehensive manner.

Therefore, the final selection of sixteen articles represents a deliberately curated set, chosen through a strict filtering process that prioritizes depth and relevance over quantity. This approach was taken not simply to limit the number of references, but to ensure that the analysis presented in this study remains focused, rigorous, and truly reflective of the most pertinent academic contributions in the field.

3. Results and Discussion

This literature-based study evaluates findings from previous research by analyzing how blockchain technology is applied across various industries in comparison to traditional systems. Based on an analysis of sixteen peer-reviewed journals, blockchain has been shown to play a significant role in transforming global supply chain management systems. These findings center on three (3) key aspects: transparency, traceability, and sustainability. However, the perspectives vary between studies—shaped by factors such as the industry sector under review, the methodological approach used, and regional focus.

Overall, previous studies agree that blockchain greatly enhances transparency in distribution flows. Studies by (Dede et al., 2021), (Osato Itohan Oriekhoe et al., 2024), and (Mahyuni et al., 2020) highlight how trust in the authenticity of data at every point of the supply chain increases when data is recorded in a decentralized and immutable manner. Regarding product traceability, researchers emphasize the importance of integrating blockchain with physical tracking technologies like RFID and QR codes (Bacchetta et al., 2021), to ensure real-time and evidence-based tracking rather than relying solely on digital records. The study by (Das Turjo et al., 2021) also underscores the critical role of data security enabled by blockchain implementation.

As noted in the studies by (Achmad Bagraff et al., 2024), (Waqar et al., 2024), (Osato Itohan Oriekhoe et al., 2024), and (Mahapatra et al., 2021), blockchain also contributes significantly to cost reduction and operational efficiency. Smart contracts that execute automatically based on pre-set conditions enable faster transactions, reduce reliance on intermediaries, and eliminate error-prone manual documentation. Nonetheless, this efficiency appears to benefit larger companies more substantially. (Dede et al., 2021), for instance, point out that blockchain adoption remains relatively costly and challenging for small businesses.

The study presented in (J et al., 2025) emphasizes that blockchain significantly contributes to enhancing transparency, data sharing, and coordination efficiency, particularly within the agri-food supply chain sector. This aligns with the focus of this review, which highlights blockchain's role in improving traceability and transparency in supply chains. On the other hand, a critical viewpoint is offered in (Bernards et al., 2024), which introduces the concept of the "veil of transparency." This study suggests that despite claims of promoting transparency and sustainability, blockchain implementation may inadvertently reinforce audit culture and managerial power structures that risk obscuring the underlying social and environmental issues present in supply chain operations. (Centobelli et al., 2022) further support this view by demonstrating how blockchain, through the Triple Retry Framework, enhances trust, traceability, and transparency in recycling, redistribution, and remanufacturing processes while reducing coordination costs and improving reverse logistics efficiency. Therefore, it is essential for decision-makers and practitioners to carefully consider how blockchain technology is applied, ensuring that its benefits genuinely align with the goals of transparency, traceability, and sustainability in supply chain management.

Several studies also explored the application of blockchain in enhancing sustainability practices, particularly in carbon footprint tracking, waste control, and green supply chain reporting. (Paliwal et al., 2020) and (Mahapatra et al., 2021) demonstrated how blockchain can be employed to verify compliance with environmental standards through real-time data collection on emissions, recycling processes, and the management of electronic waste (e-waste). Although such implementations remain largely experimental and not yet widely adopted, these studies highlight blockchain's emerging role in supporting the United Nations' Sustainable Development Goals (SDGs), particularly in promoting circularity and responsible resource management.

From a regulatory standpoint, only a few studies explicitly address how blockchain could serve as a tool for achieving mandatory compliance with legal requirements. (Tuladhar et al., 2024), for example, investigated the application of blockchain in the context of the European Union's Conflict Minerals Regulation. This reveals a considerable research gap, as most existing studies still center around voluntary corporate initiatives rather than statutory obligations. Thus, the potential of blockchain to function as a compliance engine —capable of automating regulatory verification— remains underexplored and underutilized.

In terms of social dimensions and the empowerment of marginalized actors in supply chains, this theme has been significantly overlooked. Only (Kshetri, 2022) addresses this issue directly, showing how small-scale miners can gain formal recognition and digital inclusion through blockchain technology—groups that have historically been excluded from formal systems. This presents a critical yet underappreciated opportunity for blockchain to foster social equity, fair value distribution, and labor transparency across global supply networks.

Regarding methodological approaches, most studies relied on conceptual frameworks or narrative literature reviews, as indicated in the works of (Paliwal et al., 2020) and (Osato Itohan Oriekhoe et al., 2024). Empirical implementations, however, remain scarce. For instance, (Mahapatra et al., 2021) conducted an empirical study with direct blockchain application, while others, such as (Straubert et al., 2021), focused solely on technical simulations of smart contracts without contextualizing them within real-world, complex supply chain ecosystems. In terms of industrial applications, current research remains concentrated in sectors such as food, textiles (Badhwar et al., 2023), logistics, and mining. Sectors like energy, fisheries, healthcare, and public services remain underrepresented, presenting significant opportunities for cross-sectoral and cross-jurisdictional investigations. In conclusion, while blockchain shows great promise in strengthening supply chain systems, its implementation remains fragmented and has yet to address all critical dimensions in a holistic manner. Future research would benefit from adopting interdisciplinary perspectives, incorporating social, legal, and environmental angles. Lastly, developing robust evaluation frameworks based on ESG (Environmental, Social, Governance) and SDG indicators would provide valuable tools for assessing blockchain's real impact—an area that future studies are strongly encouraged to pursue (Table 1).

Table 1. Research Gap

No.	Author & Year	Primary Focus	Application Sector	Key Contribution	Limitations / Research Gap
1	(Tuladhar et al., 2024)	Regulatory compliance (mandatory)	Minerals / Conflict Metals	Blockchain to support EU regulation	Single case study in the M&M (Minerals & Metals) industry
2	(Bacchetta et al., 2021)	Transparency + physical tracking	Manufacturing	Integration of blockchain with RFID/QR technology	No comprehensive integration testing
3	(Straubert et al., 2021)	Critique of blockchain "hype"	General	Analysis of adoption challenges and lack of trust	No implementable solutions proposed
4	(Paliwal et al., 2020)	Blockchain for green supply chains	General	Conceptual framework for sustainability	Not based on empirical case studies
5	(Badhwar et al., 2023b)	Transparency in fashion	Textile & Fashion	Design of blockchain-based traceability solution	Narrow focus on premium sector and consumers
6	(Kshetri, 2022)	Ethics & empowerment of small actors	Small-scale Mining	Blockchain to support ethics and social justice	No measurable evaluation framework proposed
7	(Mahyuni et al., 2020)	Blockchain potential for logistics performance	Logistics & SMEs	Identification of blockchain opportunities in Indonesia	No real-world implementation testing
8	(Achmad Bagraff et al., 2024)	Optimization and efficiency	General	Smart contracts to improve process efficiency	Social dimension not explored
9	(Dede et al., 2021)	Early adoption of blockchain	Pharmaceutical & Retail	Initial mapping real-world blockchain use cases	Focused on large-scale industries; not applicable for SMEs
10	(Mahapatra et al., 2021)	E-waste and blockchain	Metal Recycling	Integration of microwave treatment and smart contracts	India-only context; limited supply chain discussion
11	(Osato Itohan Oriekhoe et al., 2024)	Efficiency, transparency, innovation	Multi-sector	Comprehensive review of blockchain's role	Lacks focus on mandatory regulation and empowerment aspects
12	(Das Turjo et al., 2021)	Technical implementation of smart contracts	E-waste	Use of Hyperledger Fabric and statistical optimization	Technically focused; lacks social/economic discussions
13	(J et al., 2025)	Transparency & Efficiency Using Blockchain	Agri-food Supply Chain	Shows blockchain improve transparency, data sharing, and coordination	Focuses on operational/technical aspects; lacks governance context
14	(Bernards et al., 2024)	Blockchain & Sustainability Governance Critique	Global Supply Chains	Introduces "*veil of transparency*" concept; critiques audit culture	Conceptual, lacks concrete solution models or empirical validation
15	(Waqar et al., 2024)	Transparency and process automation	Construction	Shows blockchain's value in complex supply chains	Limited scope; lacks social and environmental insights
16	(Centobelli et al., 2022)	Enhancing trust, traceability, and transparency using blockchain	Automotive & railway industries	Proposed the Triple Retry Framework and implemented a blockchain with Hyperledger Fabric	Limited to a single case study and not yet tested across industries or global contexts

Findings from the literature review, based on sixteen (16) peer-reviewed journal articles, reveal that most studies on blockchain adoption in supply chains remain predominantly technical in nature. The primary focus lies in improving process efficiency, enhancing information transparency, and integrating blockchain with physical tracking technologies such as RFID and QR codes. Several studies also emphasize the use of smart contracts to automate transactions and reduce reliance on manual documentation. However, the approaches employed are largely theoretical or narrative, with a noticeable lack of empirical research based on real-world industrial implementation. Moreover, the industrial sectors under study remain concentrated in logistics, manufacturing, mining, and textiles—while other strategic sectors, such as renewable energy, healthcare, and fisheries, have received limited attention.

Another notable gap concerns the role of blockchain in supporting mandatory regulatory compliance and fostering social empowerment, particularly for small-scale actors in the supply chain. Of all the studies analyzed, only one explicitly examined blockchain within the framework of the European Union's Conflict Minerals Regulation, and just one highlighted its potential to provide formal access and recognition to small-scale miners. Crucial issues such as fair value distribution, decent labor practices, and social inclusiveness are rarely positioned at the center of analysis. This suggests that most of the current literature still views blockchain primarily as a tool for operational efficiency, rather than as a strategic instrument to address social and ethical challenges in modern logistics systems.

In conclusion, although blockchain holds transformative potential for revolutionizing supply chain management, its application remains narrowly focused and has yet to address broader dimensions such as social impact, legal compliance, and environmental accountability. Future research should adopt interdisciplinary approaches that holistically integrate diverse perspectives. In this regard, developing evaluation frameworks grounded in sustainability indicators—such as the UN's Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) metrics—is essential. This ensures that blockchain implementation not only delivers technical efficiency but also upholds social and environmental responsibility. A further discussion on blockchain's alignment with the SDGs and ESG criteria will be elaborated in the next section.

4. Blockchain Implementation Through the Lens of SDG & ESG

By offering a decentralized, immutable, and real-time accessible data recording system, blockchain plays a vital role in enhancing traceability, transparency, and sustainability within supply chains. This technology enables streamlined tracking and auditing by capturing every transaction and product movement from origin to end-user. In terms of transparency, blockchain reduces the risk of fraud or data tampering, as all stakeholders in the supply chain can verify the recorded information. Moreover, blockchain encourages more responsible and sustainable business practices—socially and environmentally—by providing clear and verifiable information on product origins and production processes. This perspective aligns with the Triple Bottom Line concept introduced by John Elkington, which emphasizes three core pillars of sustainability: People, Planet, and Profit (3P). It advocates that organizations must not only pursue economic gain but also be accountable for their environmental and social impacts. Over time, this framework has evolved into a broader model that incorporates two additional dimensions—Peace and Partnership—resulting in the more holistic 5P approach.

The Sustainable Development Goals (SDGs) build upon this expanded framework, comprising 17 goals that address diverse aspects of sustainable development. The SDGs are rooted in the 5P principles: People (e.g., poverty alleviation, education), Planet (e.g., environmental protection), Prosperity (economic growth and well-being, replacing "Profit"), Peace (justice and strong institutions), and Partnership (global cooperation and cross-sector collaboration). As such, the SDGs can be seen as an evolved, measurable, and globally coordinated roadmap stemming from the 3P and 5P frameworks—offering a more comprehensive structure for achieving sustainability. Meanwhile, Environmental, Social, and Governance (ESG) has emerged as a widely adopted framework, particularly within the finance and business sectors, to evaluate corporate sustainability performance and non-financial risks. Although ESG does not explicitly refer to the 3P or 5P, many of its components are closely aligned. The Environmental pillar corresponds to Planet, the social dimension relates to People, and Governance ties to elements of Peace and Partnership. ESG is often regarded as a practical instrument for operationalizing the SDGs within private sector practices, with ESG metrics frequently serving as benchmarks for corporate contributions toward SDG targets. In this way, ESG and SDGs create a mutually reinforcing relationship, bridging global sustainability goals with measurable corporate accountability.

Despite thematic convergence, SDG and ESG differ fundamentally in their scope and application. SDGs are macro-level goals designed for global and national development agendas, while ESG operates at a micro-level, helping businesses assess risks and opportunities from an investment perspective. ESG tends to be more pragmatic and investor-oriented, whereas SDG embodies normative aspirations aimed at structural global change. Therefore, these frameworks should not be viewed as substitutes, but rather as complementary: ESG can act as a mechanism for the private sector to support and accelerate SDG achievements within the broader 5P framework. Considering the findings from prior literature, future research should be directed toward developing evaluative models that measure the success of blockchain implementation through the lens of SDG and ESG integration. Such research is expected to lay the groundwork for building supply chain systems that are not only transparent, traceable, and efficient, but also socially and environmentally responsible — truly aligning technological innovation with global sustainability objectives (Figure 1).

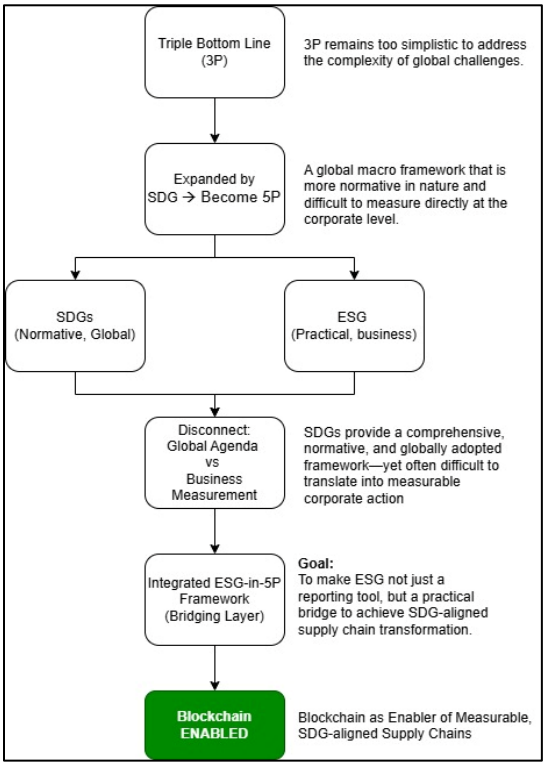

Figure 1. Conceptual Framework

5. Conclusion

Based on the analysis of sixteen (16) peer-reviewed journal articles, it can be concluded that blockchain technology plays a significant role in enhancing transparency, traceability, and sustainability in supply chain management. Its decentralized and immutable data recording system, combined with the integration of physical tracking tools such as QR codes and RFID, has strengthened the ability to trace products in real time. Moreover, the application of smart contracts improves operational efficiency and reduces costs, particularly for large-scale enterprises. In terms of sustainability, blockchain is beginning to be utilized for carbon footprint reporting and waste management. However, these applications remain limited and are still largely in the experimental stage.

The role of blockchain in supporting social justice and the empowerment of marginalized actors within supply chains, as well as in ensuring compliance with mandatory legal frameworks, is an area that remains underexplored. Most of the existing studies rely on conceptual or narrative approaches, with limited empirical investigations. Furthermore, current research tends to concentrate on specific sectors such as logistics, manufacturing, mining, and fashion, leaving important industries like healthcare, energy, public services, and disaster management relatively untouched. This indicates a clear need for broader, cross-sector, and empirical research in future studies.

Therefore, further research is recommended to adopt an interdisciplinary approach that incorporates social, legal, and environmental dimensions, along with the development of comprehensive evaluation models grounded in ESG and SDG indicators. These models are essential to gain a more holistic understanding of blockchain adoption in global supply chains. Future studies should also aim to explore its applications in under-researched sectors—particularly within developing countries—through real-world case studies that test blockchain's effectiveness in complex operational environments. A robust evaluation framework that includes not only technical and efficient aspects but also regulatory compliance, social impact, and alignment with sustainable development goals is crucial to drive the adoption of blockchain technologies in a way that is both ethically responsible and strategically aligned with global sustainability objectives.

References

Achmad Bagraff, H., Kholis, N., . M., & Ghofi Nabila, F. Implementing Blockchain Technology for Optimized Supply Chain and Enhanced Sustainability. *International Journal of Innovative Science and Research Technology (IJISRT)*, 9(8), 1697–1702, 2024. https://doi.org/10.38124/ijisrt/ijisrt24aug1218.

Bacchetta, A. v. B., Krümpel, V., & Cullen, E. Transparency with Blockchain and Physical Tracking Technologies: Enabling Traceability in Raw Material Supply Chains, 1, 2021. https://doi.org/10.3390/materproc2021005001.

Badhwar, A., Islam, S., & Tan, C. S. L. Exploring the potential of blockchain technology within the fashion and textile supply chain with a focus on traceability, transparency, and product authenticity: A systematic review. *Frontiers in Blockchain*, 6, 1–19, 2023. https://doi.org/10.3389/fbloc.2023.1044723.

Bernards, N., Campbell-Verduyn, M., & Rodima-Taylor, D. The veil of transparency: Blockchain and sustainability governance in global supply chains. *Environment and Planning C: Politics and Space*, 42(5), 742–760, 2024. https://doi.org/10.1177/23996544221142763.

Centobelli, P., Cerchione, R., Vecchio, P. Del, Oropallo, E., & Secundo, G. Blockchain technology for bridging trust, traceability and transparency in circular supply chain. *Information and Management*, 59(7), 2022. https://doi.org/10.1016/j.im.2021.103508.

Das Turjo, M., Khan, M. M., Kaur, M., & Atef, Z. Smart Supply Chain Management Using the Blockchain and Smart Contract, 1–23, 2021.

Dede, S., Köseoglu, M. C., & Yercan, H. F. Learning from early adopters of blockchain technology: A systematic review of supply chain case studies. *Technology Innovation Management Review*, 11(6), 19–31, 2021. https://doi.org/10.22215/timreview/1447.

J, R., Ashish, Boianapalli, S., M, S. S., Rashid, S. Z., & Kumar S, S. Blockchain Technology in Supply Chain Management Enhancing Transparency and Efficiency. *ITM Web of Conferences*, 76, 02011, 2025. https://doi.org/10.1051/itmconf/20257602011.

Kshetri, N. Blockchain systems and ethical sourcing in the mineral and metal industry: a multiple case study. *International Journal of Logistics Management*, 33(1), 1–27, 2022. https://doi.org/10.1108/IJLM-02-2021-0108.

Mahapatra, R. P., Srikant, S. S., Pandey, S., Chouhan, V., & Rao, R. B. Trusted and transparent blockchain-enabled E-waste optimization to recover precious metals with microwave heating. *Journal of Scientific and Industrial Research*, 80(7), 623–629, 2021. https://doi.org/10.56042/jsir.v80i7.46721.

Mahyuni, L. P., Adrian, R., Darma, G. S., Krisnawijaya, N. N. K., Dewi, I. G. A. A. P., & Permana, G. P. L. Mapping the potentials of blockchain in improving supply chain performance. *Cogent Business and Management*, 7(1), 2020. https://doi.org/10.1080/23311975.2020.1788329.

Osato Itohan Oriekhoe, Oluwaseun Peter Oyeyemi, Binaebi Gloria Bello, Ganiyu Bolawale Omotoye, Andrew Ifesinachi Daraojimba, & Adedayo Adefemi. Blockchain in supply chain management: A review of efficiency, transparency, and innovation. *International Journal of Science and Research Archive*, 11(1), 173–181, 2024. https://doi.org/10.30574/ijsra.2024.11.1.0028.

Paliwal, V., Chandra, S., & Sharma, S. Blockchain technology for sustainable supply chain management: A systematic literature review and a classification framework. *Sustainability (Switzerland)*, 12(18), 1–39, 2020. https://doi.org/10.3390/su12187638.

Straubert, C., Sucky, E., & Mattke, J. Blockchain Technology for Tracking and Tracing in Supply Chains: A Critical Viewpoint. *54th Hawaii International Conference on System Sciences*, pp. 1174–179135, 2021.

Tayal, A., Solanki, A., Kondal, R., Nayyar, A., Tanwar, S., & Kumar, N. Blockchain-based efficient communication for food supply chain industry: Transparency and traceability analysis for sustainable business. *International Journal of Communication Systems*, 34(4), 2021. https://doi.org/10.1002/dac.4696.

Tuladhar, A., Rogerson, M., Engelhart, J., Parry, G. C., & Altrichter, B. Blockchain for compliance: an information processing case study of mandatory supply chain transparency in conflict minerals sourcing. *Supply Chain Management*, 29(4), 755–777, 2024. https://doi.org/10.1108/SCM-11-2023-0585.

Waqar, A., Mateen Khan, A., & Othman, I. Blockchain empowerment in construction supply chains: Enhancing efficiency and sustainability for an infrastructure development. *Journal of Infrastructure Intelligence and Resilience*, 3(1), 2024. https://doi.org/10.1016/j.iintel.2023.100065.

Biographies

Mahasena Jonatan is currently pursuing a master's degree in industrial engineering at the Faculty of Engineering, Universitas Surabaya (Indonesia), where he previously earned his bachelor's degree in the same field with a focus on systemic problem-solving. With three years of hands-on experience in the manufacturing industry, he has developed a keen understanding of real-world supply chain challenges and operational inefficiencies. His academic journey includes pioneering research in disaster management systems during his undergraduate studies, where he designed predictive models for refugee needs during the Mount Merapi volcanic eruption – A project that highlighted his ability to merge engineering rigor with humanitarian applications. Passionate about technological innovation for social impact, his research now centers on blockchain applications in disaster response and supply chain resilience. His current work explores how decentralized ledger technology can enhance transparency, traceability, and efficiency in humanitarian logistics during crises, aiming to bridge the gap between cutting-edge technology and life-saving interventions.

Prof. Ir. Markus Hartono, B.Eng., M.Sc., Ph.D., CHFP, IPU, ASEAN Eng., GRI CSP is a Full Professor in the Industrial Engineering Study Program at the University of Surabaya (IE UBAYA). He earned his bachelor's degree in industrial engineering from IE UBAYA in 2000 with Cum Laude honors. He subsequently completed his master's degree in 2005 and Ph.D. in 2012 at the National University of Singapore (NUS), supported by the prestigious ASEAN Graduate Scholarship and the NUS Research Scholarship. Prof. Hartono holds several distinguished professional certifications, including Certified Human Factors Professional (CHFP) from the Board of Certification in Professional Ergonomics (BCPE), USA; Executive Professional Engineer (Insinyur Profesional Utama, IPU) from The Institution of Engineers Indonesia; ASEAN Engineer; and Certified Sustainability Professional (CSP) from the GRI Academy.