ADVANCING HALAL SUPPLY CHAIN PRACTICES THROUGH SUSTAINABLE INNOVATION TRANSPARENCY AND REGULATORY COMPLIANCE

PROMOVENDO PRÁTICAS DE CADEIA DE SUPRIMENTOS HALAL POR MEIO DE INOVAÇÃO SUSTENTÁVEL, TRANSPARÊNCIA E CONFORMIDADE REGULATÓRIA

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The authors declare that there is no conflict of interest

Abstract

The development of halal supply chains reflects a growing need to integrate religious integrity with modern supply chain imperatives. The analysis presented has shown that sustainability, transparency, and regulatory compliance are no longer peripheral considerations but essential pillars of advancement. Each dimension is interconnected, shaping not only operational practices but also the credibility and competitiveness of halal industries in global markets. Sustainability offers halal supply chains the ability to translate Islamic values of stewardship into practical strategies such as eco-friendly logistics, renewable energy adoption, and circular economy practices. Transparency, strengthened through digital technologies, ensures that consumers can verify halal authenticity with confidence. Yet, adoption of such innovations remains uneven, particularly among small and medium enterprises, making supportive infrastructure and inclusive policies a necessity. At the same time, fragmented regulatory frameworks continue to generate inefficiencies and weaken trust, highlighting the importance of harmonized and adaptive systems that can respond to emerging sustainability and technological demands. What emerges most

Resumo

O desenvolvimento de cadeias de abastecimento halal reflete uma necessidade crescente de integrar a integridade religiosa com os imperativos modernos da cadeia de abastecimento. A análise apresentada mostrou que a sustentabilidade, a transparência e a conformidade regulatória não são mais considerações periféricas, mas pilares essenciais do avanço. Cada dimensão está interligada, moldando não apenas as práticas operacionais, mas também a credibilidade e a competitividade das indústrias halal nos mercados globais. A sustentabilidade oferece às cadeias de abastecimento halal a capacidade de traduzir os valores islâmicos de gestão responsável em estratégias práticas, como logística ecológica, adoção de energia renovável e práticas de economia circular. A transparência, fortalecida por meio de tecnologias digitais, garante que os consumidores possam verificar a autenticidade halal com confiança. No entanto, a adoção dessas inovações continua desigual, especialmente entre pequenas e médias empresas, tornando necessárias infraestruturas de apoio e políticas inclusivas. Ao mesmo tempo, estruturas regulatórias fragmentadas continuam

clearly is the need for integrated governance models. Addressing sustainability, transparency, and regulation in isolation is insufficient. By embedding these elements within a cohesive framework, halal supply chains can move beyond compliance toward leadership in global value chains. Achieving this transformation will position halal supply chains as models of resilience, responsibility, and innovation in the evolving landscape of international trade.

Keywords: Halal. Sustainability. Innovation. Transparency. Regulation.

a gerar ineficiências e enfraquecer a confiança, destacando a importância de sistemas harmonizados e adaptáveis que possam responder às demandas emergentes de sustentabilidade e tecnologia. O que emerge mais claramente é a necessidade de modelos de governança integrados. Abordar a sustentabilidade, a transparência e a regulamentação de forma isolada é insuficiente. Ao incorporar esses elementos em uma estrutura coesa, as cadeias de abastecimento halal podem ir além da conformidade e alcançar a liderança nas cadeias de valor globais. Alcançar essa transformação posicionará as cadeias de abastecimento halal como modelos de resiliência, responsabilidade e inovação no cenário em evolução do comércio internacional.

Palavras-chave: *Halal. Sustentabilidade. Inovação. Transparência. Regulamentação.*

1 INTRODUCTION

The halal industry has become one of the fastest-growing sectors of the global economy, extending beyond its religious origins to influence food production, pharmaceuticals, cosmetics, logistics, and tourism. Once regarded as a niche segment catering primarily to Muslim consumers, halal products are now consumed widely by non-Muslim populations who associate halal with quality, cleanliness, and ethical production (Abbas *et al*., 2025). The global halal economy is projected to continue expanding significantly, driven by rising Muslim populations, higher purchasing power, and increasing mainstream recognition of halal certification as a signal of safety and integrity (Changalima, 2025). This expansion has turned halal supply chains into critical systems that must not only maintain religious compliance but also adapt to new consumer expectations of sustainability, transparency, and regulatory reliability (Moghaddam & Nof, 2022).

Halal supply chains differ fundamentally from conventional systems because they must preserve halal integrity at every stage of production and distribution. A product is either halal or non-halal, with no intermediate categories, making compliance absolute rather than relative (Susanty *et al*., 2025). A single lapse in sourcing, processing,

packaging, or transport can render a product non-halal, even if all other stages were compliant. This binary requirement increases the vulnerability of halal supply chains to disruption, fraud, and reputational damage (Sunmola *et al.*, 2025). In increasingly globalized value networks where ingredients often cross multiple jurisdictions, safeguarding integrity has become an enormous challenge (Ellahi *et al.*, 2025). With modern consumers demanding proof of authenticity and regulators imposing stricter oversight, halal supply chain management must evolve into a system that integrates sustainability, technological transparency, and harmonized regulatory compliance (McKinnon, 2018).

Sustainability is now a dominant issue across global supply chains, and halal industries are no exception. Islamic principles emphasize stewardship of the environment, moderation in consumption, and fairness in economic activity, all of which align closely with sustainability concepts (Ab Talib & Zulfakar, 2023). Yet studies indicate that many halal businesses limit their focus to obtaining certification rather than embedding sustainability throughout their operations (Putri, 2025). For instance, empirical work shows that halal-certified firms often neglect practices such as waste minimization, renewable energy adoption, and environmentally friendly packaging (Integrating Sustainability in Halal SCM, 2025). This gap between principles and practice risks undermining consumer trust, particularly in markets where environmental and social sustainability strongly influence purchasing decisions (Ghalih & Chang, 2025). Moreover, small and medium enterprises (SMEs), which dominate halal production in many regions, frequently lack the resources and expertise to adopt sustainable innovations (Ardiantono *et al.*, 2024). This disparity creates uneven progress across halal ecosystems and highlights the importance of integrating sustainability more systematically.

Transparency and traceability have also become pressing priorities. Consumers increasingly demand the ability to verify halal status across all stages of the supply chain, from farm to retail outlet (Susanty *et al.*, 2025). Traditional documentation systems are inadequate in this regard, as they rely heavily on paper-based or siloed records that are prone to error, fraud, or data loss (Yakubu *et al.*, 2025). Scholars have proposed adopting advanced digital technologies such as blockchain, Internet of Things (IoT), artificial intelligence (AI), and digital twins to overcome these weaknesses (Sunmola *et al.*, 2025). Blockchain systems, for example, can provide immutable records of halal compliance,

while IoT sensors can monitor conditions during transportation to ensure that contamination does not occur (Kurniawan *et al.*, 2025). AI algorithms can enhance decision-making by detecting anomalies or inconsistencies in certification data (Alourani & Khan, 2024). Together, these technologies offer the potential to build supply chains that are not only transparent but also trustworthy and efficient.

Despite the promise of technology, adoption has been slow and uneven. Many halal firms, especially SMEs, face barriers such as high investment costs, lack of technical expertise, and insufficient digital infrastructure (Hassam *et al.*, 2025). Interoperability issues between systems, reluctance to share sensitive information, and legal uncertainty about data ownership further complicate implementation (Holistic Framework for Halal Digitalization, 2025). While prototypes such as HalalChain (Yakubu *et al.*, 2025) and blockchain-enabled traceability platforms (Adhiwibowo *et al.*, 2025) have been developed, few have been scaled successfully across industries or geographies. As a result, many proposed frameworks remain conceptual, highlighting the need for more empirical validation and real-world deployment (Sunmola *et al.*, 2025).

Regulatory compliance adds another dimension of complexity to halal supply chains. Different countries maintain their own certification bodies and standards, such as JAKIM in Malaysia, MUI in Indonesia, IFANCA in the United States, and GSO in the Gulf region (Exploring Certifying Bodies, 2025). The absence of harmonized global standards forces companies to obtain multiple certifications when trading across borders, leading to duplication, delays, and additional costs (Changalima, 2025). Moreover, overlapping regulations from food safety, animal welfare, and environmental policies often intersect with halal certification, creating further uncertainty for businesses (Aligning Halal Supply Chain Improvements, 2025). In some regions, enforcement capacity is limited, resulting in inconsistent monitoring and the possibility of malpractice (Integrity Challenges in Halal Meat Supply Chain, 2025). This unevenness undermines consumer confidence in halal labeling and weakens the global competitiveness of halal products.

Another tension arises when rigid regulatory systems clash with innovation. Some certification protocols are slow to adapt to new technologies or sustainable practices, making it difficult for firms to experiment with novel packaging materials, digital platforms, or alternative logistics solutions (Adhiwibowo *et al.*, 2025). Regulators may

lack the expertise or institutional capacity to audit technology-driven systems, which discourages firms from investing in them (Sunmola *et al*., 2025). Without institutional innovation alongside technological innovation, halal supply chains risk stagnation. Thus, advancing regulatory harmonization and institutional learning is essential for enabling transformation (Ghalih & Chang, 2025).

Risk is a defining characteristic of halal supply chains because the consequences of non-compliance are immediate and severe. Scholars identify risks such as contamination, certification errors, fraudulent labeling, and failures in traceability as critical vulnerabilities (Integrity Challenges in Halal Meat Supply Chain, 2025). Among these, production risks are especially serious because they directly determine whether a product qualifies as halal. Fraudulent practices, including adulteration or misrepresentation of ingredients, remain pressing issues in global halal trade (Susanty *et al*., 2025). These risks underscore the need for stronger monitoring systems, advanced traceability, and robust governance structures. Because halal compliance is absolute, consumers expect zero tolerance for errors, making effective risk management non-negotiable (McKinnon, 2018).

Despite expanding interest in halal supply chain research, major gaps remain. Much of the scholarship treats sustainability, transparency, and regulation as separate silos, rather than analyzing how they intersect to shape modern supply chains (Halal Food Supply Chains: A Literature Review, 2025). Comparative analyses across countries or industries are limited, leaving gaps in understanding how context influences adoption (Kurniawati *et al*., 2023). Many proposed technological models remain conceptual or tested only in pilot projects, with little evidence of large-scale application (Alourani & Khan, 2024). The role of SMEs, which form the majority of halal producers, is underexplored despite their resource limitations and critical role in halal ecosystems (Ardiantono *et al*., 2024). Institutional mechanisms such as harmonization agreements, public-private partnerships, and certification governance reforms remain insufficiently studied (Exploring Certifying Bodies, 2025). These gaps demonstrate the need for integrative approaches that unify sustainability, transparency, and regulation into a coherent framework (Moghaddam & Nof, 2022).

The contribution of this research lies in its effort to connect these fragmented strands into a holistic perspective that acknowledges their interdependence. For academic

scholarship, it enriches the field by demonstrating that sustainable innovation, transparency, and regulation are not separate dimensions but mutually reinforcing elements of halal supply chains (Ab Talib & Zulfakar, 2023). For practitioners, it provides insights into strategies for embedding environmental responsibility, adopting digital transparency tools, and navigating complex regulatory regimes (Hassam *et al.*, 2025). For policymakers and certification authorities, it offers a foundation for developing harmonized regulations, providing incentives for sustainable practices, and investing in digital infrastructure to support transformation (McKinnon, 2018).

The halal supply chain stands at a crossroads. Rapid globalization, advances in digital technology, and growing consumer expectations have created new opportunities but also new risks. Firms that fail to adapt risk reputational loss and diminished competitiveness, while those that embrace sustainable innovation, transparent traceability, and regulatory alignment can secure long-term trust and market leadership (Sunmola *et al.*, 2025). Addressing these challenges requires moving away from fragmented approaches toward comprehensive strategies that integrate these three pillars into a cohesive system (Moghaddam & Nof, 2022). This introduction has outlined the global context, examined sustainability and transparency challenges, highlighted regulatory complexities, and identified persistent research gaps. Building on this foundation, the subsequent sections of the article will analyze these dimensions in depth and propose pathways for advancing halal supply chains to meet the demands of an interconnected and rapidly evolving world.

2 LITERATURE REVIEW

The rapid growth of the halal industry has attracted extensive scholarly attention across multiple disciplines, including logistics, food science, sustainability, and regulatory studies. While the Introduction outlined the global rise of halal supply chains and highlighted their unique challenges, this Literature Review synthesizes the current body of work related to sustainable innovation, transparency, and regulatory compliance. The aim is to provide an overview of how research has developed, identify common findings and contradictions, and outline areas where future exploration is needed. Consistent with the integrative approach established earlier, the review is organized into

five main themes: sustainability and innovation, transparency and traceability, regulatory compliance and harmonization, risks and the role of SMEs, and the move toward integrated frameworks.

2.1 Sustainability and innovation in halal supply chains

Sustainability is widely recognized as a critical driver of modern supply chain transformation, and halal systems are increasingly examined through this lens. Islamic teachings on stewardship and moderation naturally align with sustainability, making it a moral as well as managerial imperative (Ab Talib & Zulfakar, 2023). Research has shown that integrating sustainability into halal supply chains enhances not only environmental outcomes but also consumer trust, since many consumers equate halal with broader notions of wholesomeness and responsibility (Putri, 2025). Despite this alignment, empirical studies reveal that many halal-certified firms remain narrowly focused on certification and neglect sustainability initiatives such as carbon footprint reduction or waste minimization (Integrating Sustainability in Halal SCM, 2025).

Innovations in green logistics, circular economy practices, and renewable energy adoption are often underutilized in halal industries. For example, Abbas *et al*. (2025) argue that although halal food producers frequently meet religious compliance, they lag in adopting eco-friendly packaging and energy-efficient transportation. Harsanto (2024) points out that the halal sector has been slow to embrace Industry 4.0 technologies, which could significantly improve operational sustainability. In the context of Southeast Asia, Ardiantono *et al*. (2024) highlight that SMEs lack access to capital and knowledge for sustainable innovation, creating disparities within halal ecosystems.

Recent literature emphasizes the role of innovation not just in environmental performance but also in competitive advantage. Moghaddam and Nof (2022) demonstrate that supply chains integrating sustainability and innovation achieve higher resilience, a finding particularly relevant for halal markets exposed to reputational risks. Similarly, McKinnon (2025) stresses the importance of decarbonizing logistics, noting that halal transport systems could serve as exemplars by aligning environmental responsibility with religious integrity. Collectively, these studies highlight both opportunities and gaps: while

the halal concept is inherently compatible with sustainability, practical adoption of innovation remains uneven, especially among SMEs.

2.2 Transparency and traceability through technology

Transparency has become a defining issue in halal supply chain management. Consumers increasingly demand verifiable proof that halal integrity is preserved across all stages, from sourcing to retail (Susanty *et al*., 2025). Traditional systems based on paper records are inadequate, prompting calls for digital solutions. Blockchain technology has emerged as a leading candidate for enhancing transparency due to its ability to create immutable records (Yakubu *et al*., 2025). For instance, Alourani and Khan (2024) review blockchain and AI applications for halal food traceability, arguing that these technologies enhance consumer trust while reducing fraud.

IoT devices and digital twins are also being explored to monitor real-time conditions during transport and storage (Kurniawan *et al*., 2025). By embedding sensors into logistics systems, companies can ensure that halal products are not exposed to contamination risks. Sunmola *et al*. (2025) propose an integrated halal certification framework using blockchain and AI to automate compliance, while Adhiwibowo *et al*. (2025) design a dual-chain IoT model specifically for halal meat traceability. These technological approaches illustrate the growing sophistication of transparency research in halal supply chains.

Despite their promise, challenges remain. Hassam *et al*. (2025) note that MSMEs in Malaysia struggle with the costs and complexity of adopting blockchain. Interoperability between systems and resistance to data sharing also impede widespread adoption (Holistic Framework for Halal Digitalization, 2025). Moreover, empirical validation is limited; many studies present conceptual models without testing them in real-world, multi-actor supply chains (Sunmola *et al*., 2025). Comparative studies across different geographies are rare, leaving unanswered questions about scalability in diverse regulatory and cultural contexts.

2.3 Regulatory compliance and global harmonization

Regulatory compliance has been a central focus of halal supply chain literature, reflecting the complex and fragmented nature of certification systems worldwide. Countries such as Malaysia, Indonesia, and Gulf states have developed strong national certification frameworks, but their lack of harmonization creates barriers for international trade (Exploring Certifying Bodies, 2025). Changalima (2025) notes that companies operating across borders often face duplicative audits and certification costs, undermining efficiency and discouraging innovation.

Research increasingly calls for global harmonization of halal standards. Ghalih and Chang (2025) argue that alignment in certification would reduce inefficiencies and enable smoother trade flows, while Sunmola *et al*. (2025) emphasize the importance of regulatory frameworks that can incorporate technological solutions like blockchain. At the same time, McKinnon (2025) highlights the challenge of reconciling halal certification with broader regulatory regimes in logistics and sustainability, such as decarbonization and food safety laws.

Weak enforcement in certain regions exacerbates risks of malpractice and fraud. Integrity Challenges in Halal Meat Supply Chain (2025) documents instances of fraudulent labeling where regulatory oversight is insufficient. Moreover, certification bodies may lack the technical capacity to audit or recognize innovations in sustainability and transparency, creating a regulatory lag (Adhiwibowo *et al*., 2025).

2.4 Risks, vulnerabilities, and the role of SMEs

Risk is a central theme in halal supply chain literature because the binary nature of halal compliance magnifies the consequences of failure. Integrity Challenges in Halal Meat Supply Chain (2025) categorizes risks into production, contamination, certification errors, and traceability failures. Production risk, such as the use of non-halal ingredients, is identified as the most critical, but logistical contamination and certification fraud also pose serious threats (Susanty *et al*., 2025).

Research highlights the vulnerability of SMEs, which constitute the majority of halal producers globally. Ardiantono *et al*. (2024) show that SMEs often lack financial

and technical capacity to adopt advanced transparency or sustainability practices. Hassam *et al*. (2025) similarly find that MSMEs face significant barriers in blockchain adoption. This creates a two-tiered halal ecosystem in which larger firms advance while smaller actors lag, undermining overall supply chain integrity.

Studies emphasize that consumer trust is easily eroded by integrity failures. Ellahi *et al*. (2025) argue that even minor breaches in halal assurance can have disproportionate reputational effects. Fraudulent practices such as mislabeling are particularly damaging, as they call into question the reliability of entire certification systems (Exploring Certifying Bodies, 2025). Addressing these risks requires stronger governance, more robust monitoring, and greater support for SMEs to build capacity.

From a resilience perspective, Moghaddam and Nof (2022) highlight that supply chains integrating sustainability and transparency are better equipped to manage risks. However, the literature also indicates that more empirical studies are needed to understand how SMEs can be effectively included in these transformations. Without inclusive strategies, vulnerabilities will persist, limiting the advancement of halal supply chains.

2.5 Towards integrated frameworks of sustainability, transparency, and regulation

One of the most consistent critiques in the literature is that sustainability, transparency, and regulatory compliance are often studied in isolation. Halal Food Supply Chains: A Literature Review (2025) highlights this fragmentation, noting that most studies fail to address the interconnections among these domains. This gap has led to calls for integrative frameworks that can account for the complexity of halal supply chains.

Recent attempts at integration are promising but incomplete. Sunmola *et al*. (2025) propose a holistic framework combining AI and blockchain within certification processes, while Yakubu *et al*. (2025) present HalalChain as a decentralized model. However, both remain at conceptual stages. McKinnon (2025) argues that integration must also extend to logistics and decarbonization, ensuring that halal supply chains align with broader global goals.

Integrating sustainability, transparency, and regulation offers several advantages. It ensures that innovations are recognized by regulators, that transparency systems build

consumer trust, and that sustainability enhances both compliance and competitiveness (Ab Talib & Zulfakar, 2023). Moghaddam and Nof (2022) contend that such integration strengthens resilience and enables supply chains to adapt to uncertainty. Still, the literature acknowledges significant gaps in empirical validation and practical implementation.

The movement toward integration reflects a broader trend in supply chain management: recognizing that resilience and trust depend on interconnected systems rather than isolated measures. For halal supply chains, this realization is especially urgent given the binary nature of compliance and the rising expectations of global markets.

3 ISSUES IN ADVANCING HALAL SUPPLY CHAIN PRACTICES

The halal supply chain has emerged as an essential component of the global halal economy, ensuring that products and services meet the requirements of Shariah principles while also addressing broader consumer expectations of quality, safety, and ethical conduct. The literature review demonstrated that while progress has been made in areas such as sustainability, transparency, and regulation, multiple unresolved challenges continue to hinder advancement. Understanding these issues is critical because they directly influence the competitiveness, credibility, and resilience of halal supply chains. They also determine whether halal industries can keep pace with global supply chain transformations. This section discusses five major issues that remain pressing: the insufficient integration of sustainability, persistent transparency gaps, regulatory fragmentation, risks faced particularly by SMEs, and the lack of integrative frameworks.

3.1 Insufficient integration of sustainability in halal supply chains

Sustainability is one of the most significant global supply chain concerns, yet halal supply chains often demonstrate limited integration of environmental and social responsibility practices. While Islamic values inherently promote stewardship of the earth and responsible consumption, many halal enterprises still perceive sustainability as separate from halal compliance (Ab Talib & Zulfakar, 2023). Studies highlight that businesses frequently treat halal certification as an end in itself, focusing only on religious

compliance while overlooking sustainability dimensions such as reducing carbon emissions, minimizing waste, or adopting renewable energy (Putri, 2025). This narrow view restricts the sector from aligning fully with global sustainability agendas.

Several empirical investigations confirm this gap. Abbas *et al.* (2025) find that halal food producers, although effective in meeting certification standards, often lag in eco-friendly packaging and energy efficiency. Similarly, Harsanto (2024) emphasizes that halal industries are slower than others in adopting Industry 4.0 innovations, which could significantly enhance environmental performance. Integrating sustainability also requires investment in technology, infrastructure, and human capital, resources that SMEs frequently lack (Ardiantono *et al.*, 2024).

The problem is not merely one of awareness but also of incentives. Research by Ghalih and Chang (2025) indicates that certification systems rarely require or reward sustainability practices, meaning that firms have little institutional motivation to integrate them. Although sustainability is increasingly demanded by consumers, the absence of regulatory enforcement and harmonized certification guidelines creates inconsistent practices across markets (Integrating Sustainability in Halal SCM, 2025). Without addressing this issue, halal supply chains risk being perceived as outdated, missing opportunities to position themselves as leaders in ethical and responsible supply chain management.

3.2 Transparency and traceability gaps in global halal networks

Transparency and traceability are critical for maintaining consumer trust, yet they remain weak in many halal supply chains. Traditional certification and auditing systems often rely on fragmented, paper-based processes that are vulnerable to manipulation and human error (Ellahi *et al.*, 2025). This lack of robust traceability creates vulnerabilities, especially in global supply chains where products cross multiple jurisdictions before reaching end consumers (Susanty *et al.*, 2025).

Technological innovations such as blockchain, artificial intelligence, and Internet of Things (IoT) have been proposed to improve transparency. Blockchain, in particular, offers immutable records that can authenticate halal claims (Yakubu *et al.*, 2025). Adhiwibowo *et al.* (2025) design a dual-chain IoT model for halal meat traceability, while

Sunmola *et al.* (2025) propose a holistic certification framework that integrates AI and blockchain. Despite their promise, the adoption of these technologies remains limited. Hassam *et al.* (2025) report that many SMEs in Malaysia lack the financial capacity and technical expertise to implement blockchain systems.

Moreover, many of these solutions remain conceptual or limited to pilot studies. Kurniawan *et al.* (2025) present a blockchain-IoT traceability model in Indonesia but emphasize that its scalability remains untested. Holistic Framework for Halal Digitalization (2025) identifies challenges such as interoperability between systems, resistance from intermediaries to share data, and uncertainties about data governance. These constraints slow the transition from theory to practice.

The lack of effective traceability has serious consequences. Fraudulent labeling and contamination scandals erode consumer trust not only in individual firms but in halal certification systems as a whole (Integrity Challenges in Halal Meat Supply Chain, 2025). With consumers increasingly demanding real-time verification of product authenticity, the persistence of transparency gaps represents a significant obstacle to the modernization of halal supply chains.

3.3 Regulatory fragmentation and inconsistent standards

Regulatory fragmentation is one of the most pressing challenges facing halal supply chains. Certification standards vary widely between countries and regions, with organizations such as JAKIM in Malaysia, MUI in Indonesia, IFANCA in the United States, and GSO in the Gulf states applying different rules and procedures (Exploring Certifying Bodies, 2025). This diversity reflects local contexts but also creates barriers to international trade. Companies operating across multiple markets often face duplicative audits, inconsistent certification requirements, and increased costs (Changalima, 2025).

The absence of harmonized standards undermines efficiency and discourages innovation. Ghalih and Chang (2025) argue that without regulatory alignment, firms hesitate to invest in advanced technologies because it is unclear whether regulators in different countries will recognize them. Regulatory inconsistency also complicates sustainability efforts. For example, McKinnon (2018) highlights how global supply

chains are increasingly pressured to decarbonize logistics, yet halal certification systems rarely incorporate such environmental requirements.

Weak enforcement further exacerbates the problem. Integrity Challenges in Halal Meat Supply Chain (2025) documents instances of fraudulent practices where oversight is inadequate. In some markets, certification bodies are underfunded and lack the technical expertise to audit innovative processes (Adhiwibowo *et al*., 2025). This regulatory lag discourages experimentation and modernization, leaving halal industries vulnerable to malpractice and reputational risk.

Calls for global harmonization are growing. Sunmola *et al*. (2025) advocate for certification systems that incorporate technological tools, while Halal Food Supply Chains: A Literature Review (2025) identifies standardization as a critical area for future research. Yet, despite these discussions, progress toward harmonized regulation remains slow. Until this issue is resolved, halal supply chains will continue to face inefficiencies, duplication, and trust deficits.

3.4 Risks, vulnerabilities, and the constraints of SMEs

Risk is inherent in halal supply chains because compliance is absolute: a product is either halal or not, with no middle ground. This binary characteristic magnifies the consequences of failure. Integrity Challenges in Halal Meat Supply Chain (2025) identifies production risks, logistical contamination, certification errors, and traceability failures as critical vulnerabilities. Fraudulent practices such as mislabeling or adulteration remain particularly damaging, as they compromise not only individual firms but also entire halal certification systems (Susanty *et al*., 2025).

SMEs face the greatest exposure to these risks. They dominate halal industries in many regions but often lack the financial resources, technical skills, and infrastructure needed to adopt advanced sustainability and transparency practices (Ardiantono *et al*., 2024). Hassam *et al*. (2025) confirm that MSMEs in Malaysia face high costs and complexity when attempting to adopt blockchain. Without adequate support, SMEs remain vulnerable to lapses in compliance and integrity.

Research also indicates that consumer trust can be easily eroded by even small failures. Ellahi *et al*. (2025) demonstrate that breaches of halal integrity create

disproportionate reputational damage. Fraud or contamination in one firm often reduces trust across the industry as a whole. Strengthening risk management, therefore, is not only a business imperative but also an industry-wide necessity.

From a resilience perspective, Moghaddam and Nof (2022) show that integrating sustainability and transparency reduces vulnerabilities by building adaptability into supply chains. Yet the literature reveals a lack of inclusive strategies that enable SMEs to benefit from these transformations. Without addressing SME constraints, the halal industry risks developing a two-tier system where larger firms modernize while smaller ones remain exposed to risk.

3.5 Lack of integrated frameworks connecting sustainability, transparency, and regulation

Perhaps the most fundamental issue in the current literature and practice is the absence of integrated frameworks that connect sustainability, transparency, and regulation. Studies often examine these dimensions in isolation, leading to fragmented solutions (Halal Food Supply Chains: A Literature Review, 2025). While sustainability research emphasizes environmental and social responsibility, transparency studies focus on technological innovations, and regulatory discussions center on harmonization, few scholars explore how these elements interact.

Some efforts at integration exist but remain limited. Sunmola *et al*. (2025) propose a holistic certification framework combining AI and blockchain, while Yakubu *et al*. (2025) present HalalChain as a decentralized solution for traceability. McKinnon (2025) argues that halal supply chains should also align with broader global goals such as decarbonization. However, most of these frameworks are conceptual and lack empirical validation across diverse contexts.

The absence of integrated models creates inefficiencies and slows progress. Firms may invest in sustainability initiatives that are not recognized by regulators, or adopt transparency technologies that consumers do not fully trust. Regulatory agencies may enforce standards that discourage innovation rather than support it (Adhiwibowo *et al*., 2025). Moghaddam and Nof (2022) highlight that resilience depends on systems thinking,

where interconnected challenges are addressed simultaneously. Without integrated frameworks, halal supply chains risk fragmentation and stagnation.

The need for integration is urgent, as consumers, regulators, and global markets increasingly expect supply chains to deliver not only compliance but also ethical and sustainable performance. Developing such frameworks requires collaboration among businesses, policymakers, and certification bodies, as well as more empirical research across contexts. Until this issue is addressed, halal supply chains will struggle to fulfill their potential as global exemplars of responsible supply chain management.

4 DISCUSSION ON ADVANCING HALAL SUPPLY CHAINS

The issues outlined earlier reveal that halal supply chains face a complex set of challenges involving sustainability integration, transparency, regulatory fragmentation, risk exposure, and the absence of integrated frameworks. However, identifying these issues is only a first step. A deeper discussion is needed to understand how the halal industry can address them in a way that is practical, inclusive, and globally competitive. Discussion in scholarly work provides an opportunity to synthesize findings, compare them with prior studies, and explore implications for theory, practice, and policy. In line with this objective, the following subsections discuss five critical areas that emerge from the literature and the identified issues: advancing sustainability integration, enhancing transparency through digital transformation, addressing regulatory fragmentation, strengthening risk management and SME capacity, and developing integrated frameworks for the future of halal supply chains.

4.1 Advancing sustainability integration in halal supply chains

Sustainability represents one of the most urgent challenges for supply chain management globally, and halal supply chains are no exception. Despite the natural alignment between Islamic values of stewardship and sustainability, evidence shows that halal firms often stop at certification without incorporating broader environmental or social practices (Ab Talib & Zulfakar, 2023; Putri, 2025). This creates a gap between consumer expectations and industry practices. In global markets where consumers

increasingly demand environmentally friendly and socially responsible products, halal industries risk being seen as lagging if sustainability remains marginal.

Discussion in recent research emphasizes the importance of embedding sustainability into the very definition of halal supply chain excellence. Abbas *et al*. (2025) argue that halal products should be marketed not only as religiously compliant but also as environmentally superior, thereby appealing to wider markets. Similarly, Harsanto (2024) stresses the need for halal logistics to adopt Industry 4.0 innovations such as energy-efficient warehousing and digital monitoring to reduce emissions. Integrating sustainability is not just a matter of competitive advantage but also of legitimacy, as younger consumers in particular expect companies to demonstrate ethical commitments beyond minimum requirements (Ellahi *et al*., 2025).

One path forward is to redesign halal certification systems to reward sustainable practices. Ghalih and Chang (2025) recommend expanding certification frameworks to include sustainability indicators such as carbon reduction, renewable energy adoption, and fair labor standards. This would align halal certification with global sustainability agendas and strengthen consumer trust. Moreover, McKinnon (2025) highlights that logistics decarbonization is central to global supply chain transformation, and halal transport networks could set benchmarks by linking environmental targets with religious compliance.

Challenges persist, particularly for SMEs that lack financial and technical capacity to implement sustainability initiatives (Ardiantono *et al*., 2024). Solutions must therefore include supportive policies, subsidies, and capacity-building programs to help smaller firms integrate green practices (Hassam *et al*., 2025). Overall, advancing sustainability requires a systemic shift in mindset, where halal integrity is understood as encompassing not only religious compliance but also environmental and social stewardship.

4.2 Enhancing transparency and traceability through digital transformation

Transparency has become a central determinant of consumer trust in halal supply chains. As Susanty *et al*. (2025) note, consumers demand reliable, verifiable proof that products are halal from farm to fork. Yet transparency remains a major weakness due to reliance on paper-based or fragmented record systems that are prone to fraud and error

(Integrity Challenges in Halal Meat Supply Chain, 2025). The discussion now centers on how digital transformation can fill these gaps.

Technologies such as blockchain, artificial intelligence, and IoT are frequently highlighted as solutions. Blockchain, with its immutable ledger, offers the ability to record every step in a product's journey, while IoT devices can provide real-time monitoring of logistics conditions to prevent contamination (Yakubu *et al*., 2025; Kurniawan *et al*., 2025). Sunmola *et al*. (2025) propose combining blockchain with AI to create intelligent certification systems capable of detecting anomalies, while Adhiwibowo *et al*. (2025) design a dual-chain IoT model for halal meat traceability. These innovations represent important steps toward building consumer trust through technological transparency.

Nevertheless, adoption remains slow, especially among SMEs that dominate halal ecosystems. Hassam *et al*. (2025) document how Malaysian MSMEs struggle with the high cost and complexity of blockchain adoption. Moreover, issues of interoperability, data governance, and resistance to sharing proprietary information hinder broader implementation (Holistic Framework for Halal Digitalization, 2025). The gap between conceptual models and real-world deployment also remains wide. Many proposed frameworks remain in pilot stages, with few scaled applications (Alourani & Khan, 2024).

This raises questions about inclusivity in digital transformation. Without institutional support and infrastructure, SMEs risk being excluded from technological innovations, creating uneven progress within halal industries (Ardiantono *et al*., 2024). Policy incentives, such as subsidies for digital adoption or shared blockchain platforms, could help overcome these barriers (Exploring Certifying Bodies, 2025). Ultimately, enhancing transparency requires not only technological innovation but also governance structures that ensure equal participation and recognition across the supply chain.

4.3 Addressing regulatory fragmentation and pathways to harmonization

Regulatory inconsistency across countries is widely acknowledged as one of the most significant obstacles to advancing halal supply chains. Certification systems vary, with Malaysia's JAKIM, Indonesia's MUI, and the Gulf's GSO applying different standards and processes (Exploring Certifying Bodies, 2025). This lack of harmonization

creates duplicative audits, additional costs, and inefficiencies for firms engaged in global trade (Changalima, 2025).

The discussion in the literature emphasizes that fragmented regulations undermine both trust and innovation. Firms hesitate to adopt sustainability or transparency practices when it is unclear whether these will be recognized across multiple jurisdictions (Ghalih & Chang, 2025). Moreover, regulators themselves often lag in recognizing technological solutions, such as blockchain-based certification systems (Adhiwibowo *et al*., 2025). Weak enforcement in some regions further compounds the problem, allowing fraudulent practices to persist (Integrity Challenges in Halal Meat Supply Chain, 2025).

Scholars propose harmonization as a pathway forward. Sunmola *et al*. (2025) recommend establishing global halal governance structures that integrate technology into certification, while Halal Food Supply Chains: A Literature Review (2025) identifies standardization as a priority for future research. McKinnon (2018) also underscores that harmonization should extend to environmental dimensions, ensuring that halal certification aligns with global goals such as decarbonization.

Achieving harmonization, however, is politically complex. Certification bodies are often tied to national identity and sovereignty, making international agreements challenging (Changalima, 2025). Nonetheless, collaborative platforms, mutual recognition agreements, and international forums could help build consensus. For the halal industry to thrive globally, regulatory harmonization is not optional but essential, as it reduces inefficiencies, enhances consumer trust, and encourages innovation.

4.4 Strengthening risk management and SME capacity in halal supply chains

Halal supply chains are uniquely vulnerable to risks because compliance is absolute. Even a minor lapse can compromise the halal status of a product, leading to reputational and financial damage (Susanty *et al*., 2025). Risks include production errors, contamination during transport, fraudulent labeling, and certification failures (Integrity Challenges in Halal Meat Supply Chain, 2025). These risks are particularly acute for SMEs, which dominate halal industries but often lack resources for advanced risk management (Ardiantono *et al*., 2024).

Discussion in recent research highlights that SMEs face systemic constraints. Hassam *et al*. (2025) show that the costs of adopting blockchain for transparency are prohibitive for small firms. Similarly, Putri (2025) demonstrates that SMEs often neglect sustainability practices due to lack of capacity. This creates a two-tier halal ecosystem in which larger firms modernize while smaller players remain vulnerable, undermining overall supply chain integrity.

Strengthening risk management requires both technological and institutional measures. Technologically, systems such as blockchain and IoT can help monitor compliance in real time (Yakubu *et al*., 2025). Institutionally, governments and certification bodies must invest in capacity-building programs to equip SMEs with the knowledge and tools needed to maintain integrity (Exploring Certifying Bodies, 2025).

Consumer trust remains fragile. Ellahi *et al*. (2025) observe that even isolated incidents of fraud damage the reputation of entire certification systems. This means that strengthening SME capacity is not only about business survival but also about safeguarding consumer trust in halal labels globally. From a resilience perspective, Moghaddam and Nof (2022) emphasize that integrating sustainability and transparency practices strengthens supply chains against shocks. Inclusive strategies that enable SMEs to participate in modernization efforts are therefore critical.

4.5 Toward integrated and inclusive frameworks for sustainable halal supply chains

Perhaps the most important discussion emerging from the literature is the need for integrated frameworks that connect sustainability, transparency, and regulation. As Halal Food Supply Chains: A Literature Review (2025) points out, most studies address these dimensions separately, leading to fragmented solutions. This siloed approach slows progress and creates inefficiencies.

Some attempts at integration exist. Sunmola *et al*. (2025) propose combining blockchain and AI within certification systems, while Yakubu *et al*. (2025) develop HalalChain as a decentralized traceability tool. McKinnon (2025) extends the discussion to logistics decarbonization, urging halal industries to align with global sustainability agendas. Yet these frameworks remain largely conceptual and lack empirical validation across diverse contexts.

The discussion suggests that integrated frameworks offer several benefits. They ensure that sustainability initiatives are recognized by regulators, that transparency tools strengthen consumer trust, and that harmonization supports global trade. Moghaddam and Nof (2022) highlight that resilience in supply chains depends on systems thinking, where interconnected challenges are addressed simultaneously.

However, integration also requires inclusivity. Without support for SMEs, integrated frameworks risk excluding the majority of halal producers. Policymakers must therefore design inclusive governance models, provide incentives for sustainable practices, and invest in digital infrastructure that benefits all stakeholders (Ghalih & Chang, 2025). The future of halal supply chains depends on such integrative and inclusive approaches.

5 SUGGESTIONS FOR ADVANCING HALAL SUPPLY CHAIN PRACTICES

The discussion of current issues highlighted that halal supply chains face pressing challenges relating to sustainability integration, transparency gaps, regulatory fragmentation, risks for SMEs, and the lack of integrated frameworks. To move beyond identifying these issues, concrete and actionable suggestions are required that can guide both academics and practitioners in advancing halal supply chains to meet global expectations. Suggestions in this context serve as prescriptive strategies grounded in the literature, offering practical pathways that align with Islamic principles while enhancing competitiveness, resilience, and trust. The following subsections outline five major suggestions that build directly on the issues and discussion: embedding sustainability into certification and operations, accelerating digital transformation for transparency, developing harmonized regulatory frameworks, strengthening SME capacity and risk management, and creating integrated governance models.

5.1 Embedding sustainability into halal certification and operations

A major gap identified in the literature is the insufficient integration of sustainability into halal supply chains. While Islamic teachings inherently promote stewardship and responsible consumption, many halal businesses limit their focus to compliance with religious requirements, neglecting environmental and social dimensions (Ab Talib & Zulfakar, 2023). A first suggestion is therefore to embed sustainability explicitly within halal certification standards and operational practices.

Certification bodies can expand their criteria to include sustainability indicators. For example, eco-friendly packaging, renewable energy adoption, carbon footprint reporting, and fair labor practices could become recognized aspects of halal certification (Ghalih & Chang, 2025). By doing so, firms will have an institutional incentive to align halal integrity with global sustainability agendas. Research shows that consumers are increasingly attentive to both halal assurance and environmental responsibility, and combining these two dimensions can enhance market appeal (Abbas *et al*., 2025; Ellahi *et al*., 2025).

At the operational level, companies should adopt circular economy principles such as waste minimization, recycling, and energy efficiency. McKinnon (2025) emphasizes that decarbonizing logistics is central to future supply chains, and halal industries could take leadership by integrating low-emission transport and warehousing systems. Harsanto (2024) also highlights the role of Industry 4.0 technologies in achieving operational sustainability, suggesting that halal logistics adopt smart energy systems and automated monitoring.

Supporting SMEs in this process is critical. Many small firms lack the resources to implement sustainability initiatives (Ardiantono *et al*., 2024). Subsidies, training, and shared infrastructure provided by governments and industry associations can lower barriers (Hassam *et al*., 2025). Integrating sustainability into halal certification and operations would thus not only align with Islamic values but also elevate halal industries as exemplars of ethical and responsible business.

5.2 Accelerating digital transformation for transparency and traceability

Transparency is a cornerstone of consumer trust in halal supply chains, yet current systems are often inadequate. A second suggestion is to accelerate digital transformation by mainstreaming technologies such as blockchain, artificial intelligence, and IoT across halal industries. These technologies can enhance traceability, reduce fraud, and provide real-time data that reassures consumers of halal authenticity (Yakubu *et al*., 2025; Kurniawan *et al*., 2025).

Blockchain systems can create tamper-proof records of halal certification, offering immutable verification of sourcing, processing, and distribution. AI can be used to detect anomalies in certification data, while IoT sensors can monitor logistics conditions to prevent contamination (Adhiwibowo *et al*., 2025; Sunmola *et al*., 2025). Integrating these technologies provides a holistic solution that addresses current transparency gaps.

However, widespread adoption requires overcoming barriers. SMEs often face financial, technical, and infrastructural challenges in adopting advanced technologies (Hassam *et al*., 2025). To address this, governments and certification bodies can establish shared blockchain platforms and subsidized digital adoption programs. Holistic Framework for Halal Digitalization (2025) suggests that interoperability and governance issues must be resolved to ensure scalability.

Case studies indicate that consumers are willing to pay a premium for products with transparent, verifiable halal certification (Susanty *et al*., 2025). Thus, accelerating digital transformation not only strengthens compliance but also enhances competitiveness. Policymakers should prioritize the development of national and regional halal blockchain systems, linked to global platforms, ensuring interoperability and consumer trust worldwide.

5.3 Developing harmonized and adaptive regulatory frameworks

Regulatory fragmentation remains a serious obstacle to global halal trade. A third suggestion is to develop harmonized and adaptive regulatory frameworks that reduce inconsistencies while encouraging innovation. Currently, certification systems vary widely, creating inefficiencies and duplication (Exploring Certifying Bodies, 2025;

Changalima, 2025). Harmonization is therefore necessary for global market expansion and consumer confidence.

Mutual recognition agreements between certification bodies could serve as a starting point. For example, if JAKIM in Malaysia and MUI in Indonesia recognized each other's standards, firms could avoid duplicative certification. Over time, international halal governance platforms could establish core global standards, while allowing for local adaptations (Sunmola *et al*., 2025).

Adaptive regulation is equally important. As new technologies such as blockchain are introduced, certification systems must be flexible enough to audit and recognize them (Adhiwibowo *et al*., 2025). McKinnon (2018) argues that regulatory frameworks must also align with global decarbonization goals, integrating sustainability into halal certification. Without adaptive capacity, regulations risk becoming rigid barriers rather than enablers of progress.

Enforcement is another critical factor. Weak monitoring in some regions allows fraudulent practices to persist, undermining global trust (Integrity Challenges in Halal Meat Supply Chain, 2025). Strengthening enforcement requires capacity building, better funding for certification bodies, and international cooperation in auditing practices (Ellahi *et al*., 2025).

Developing harmonized and adaptive frameworks will not be simple due to political and cultural sensitivities, but it is necessary. Global halal industries can only achieve efficiency, innovation, and trust if certification systems are coherent, flexible, and internationally recognized.

5.4 Strengthening SME capacity and risk management

SMEs form the backbone of halal industries, yet they face disproportionate risks due to limited resources. A fourth suggestion is to prioritize strengthening SME capacity and risk management through financial, technical, and institutional support. Without inclusive strategies, the modernization of halal supply chains will remain uneven.

Ardiantono *et al*. (2024) emphasize that SMEs lack the financial resources and expertise to adopt sustainability practices, while Hassam *et al*. (2025) document the barriers to digital adoption. This creates a two-tier system where large firms advance but

small ones fall behind, leaving the supply chain vulnerable. Consumer trust can be damaged by even minor failures, as fraudulent practices or contamination in one SME can taint the reputation of the entire industry (Ellahi *et al*., 2025; Susanty *et al*., 2025).

Supporting SMEs requires targeted policies. Governments can provide subsidies for digital technology, training in sustainability, and low-interest financing for infrastructure upgrades (Ghalih & Chang, 2025). Industry associations can create shared resources such as blockchain platforms or eco-friendly logistics services. Certification bodies can introduce scaled requirements for SMEs, making compliance feasible without compromising integrity (Exploring Certifying Bodies, 2025).

Risk management must also be strengthened through advanced monitoring and consumer engagement. IoT systems, for example, can allow SMEs to monitor halal integrity during storage and transport at relatively low cost (Kurniawan *et al*., 2025). Moghaddam and Nof (2022) demonstrate that integrating sustainability and transparency reduces vulnerabilities by creating more resilient systems. By equipping SMEs with tools and support, the halal industry can reduce systemic risks and build inclusive growth.

5.5 Building integrated and inclusive governance models

The final suggestion is to build integrated and inclusive governance models that connect sustainability, transparency, and regulation into a coherent framework. Current approaches are often fragmented, with each dimension treated separately (Halal Food Supply Chains: A Literature Review, 2025). This slows progress and limits the effectiveness of reforms.

Integrated governance would ensure that sustainability initiatives are recognized within certification, that transparency systems are interoperable, and that regulations incentivize rather than hinder innovation. Sunmola *et al*. (2025) propose frameworks combining AI and blockchain into certification, while Yakubu *et al*. (2025) develop HalalChain as a decentralized traceability model. McKinnon (2025) extends this logic to logistics, suggesting that halal supply chains align with global environmental goals.

Inclusivity is equally critical. Without mechanisms to support SMEs, integrated frameworks risk benefiting only large corporations (Ardiantono *et al*., 2024). Policymakers must ensure that governance models are designed to accommodate different

firm sizes and capacities. This can be achieved through tiered compliance requirements, shared infrastructure, and continuous stakeholder dialogue (Exploring Certifying Bodies, 2025).

Moghaddam and Nof (2022) argue that resilience requires systems thinking, where interconnected challenges are addressed holistically. For halal supply chains, this means that sustainability, transparency, and regulation cannot be pursued in isolation. Building integrated and inclusive governance models will ensure that the industry remains credible, competitive, and responsive to global changes.

6 CONCLUSION

The advancement of halal supply chains reflects the growing complexity of global commerce where religious integrity must coexist with modern demands for sustainability, transparency, and regulatory coherence. Halal certification alone is no longer sufficient to secure consumer trust or competitiveness. The industry must embrace a broader vision in which halal integrity is expressed through ethical stewardship of the environment, transparent systems of accountability, and harmonized governance across diverse markets.

Sustainability represents a vital dimension of this transformation. Islamic principles of moderation and responsibility align naturally with environmental priorities, yet many halal enterprises continue to treat sustainability as secondary. Embedding renewable energy adoption, waste reduction strategies, and low-carbon logistics into certification and operations can reposition halal industries as leaders in responsible production. Such practices not only strengthen credibility but also create opportunities for halal products to appeal to both Muslim and non-Muslim consumers seeking ethically grounded goods.

Transparency is equally essential. Paper-based documentation and fragmented systems are inadequate in addressing fraud and maintaining consumer confidence. Emerging technologies such as blockchain, artificial intelligence, and the Internet of Things can provide verifiable traceability, real-time monitoring, and stronger accountability. However, adoption remains uneven, particularly among small and medium enterprises. Without targeted support, subsidies, and shared infrastructure, the

benefits of digital transformation risk remaining confined to larger firms, reinforcing inequality within the sector.

Regulatory fragmentation presents another obstacle. The lack of harmonized standards results in duplicative certifications and inefficiencies, while weak enforcement enables malpractice. Developing adaptive and internationally recognized frameworks is essential to reducing barriers and encouraging innovation. These frameworks must also evolve to recognize sustainability and digital solutions.

The way forward lies in integrated governance models that unite sustainability, transparency, and regulation into a cohesive approach. By advancing in this direction, halal supply chains can safeguard religious integrity while simultaneously establishing themselves as global benchmarks of ethical, resilient, and responsible supply chain management.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

How to cite this article (APA)

Yusof, M. S., Ibrahim, N. Z. M., & Othman, A. A. (2026). ADVANCING HALAL SUPPLY CHAIN PRACTICES THROUGH SUSTAINABLE INNOVATION TRANSPARENCY AND REGULATORY COMPLIANCE. Veredas Do Direito, 23(4), e234736. https://doi.org/10.18623/rvd.v23.n4.4736