ERSUD
Journal of Economic Resilience and Sustainable Development
ERSUD 2(2): 77–94
ISSN 3047-0064

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Integrated halal assurance ecosystem (IHAE): The first step to integrate halal industry's supply chain with smart halal contract agreement (SHCA)

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Received Date: June 24, 2025 Revised Date: August 10, 2025 Accepted Date: August 31, 2025

ABSTRACT

Background: Indonesia plays a pivotal role in the global halal industry, yet its certification system remains largely administrative and inspection-based, creating gaps in compliance, traceability, and export readiness. This study proposes the Integrated Halal Assurance Ecosystem (IHAE) as a process- and technology-driven framework to ensure continuous halal integrity and enhance global competitiveness. Unlike existing models in Malaysia, the UAE, and Thailand that apply sectoral solutions, IHAE offers an integrated approach across the entire supply chain. **Methods**: Using a qualitative descriptive method combined with Problem Tree Analysis, SWOT, and PESTLE, this study identifies three key weaknesses in Indonesia's halal system: the perception of certification as mere administration, the lack of real-time audit and supply chain integration, and the absence of an export readiness framework for halal micro, small, and medium enterprises (MSMEs). **Findings:** Findings highlight five strategic innovations: Halal Assurance Protocol (HAP), Halal Assurance Network (HAN), Smart Halal Contract Agreement (SHCA), Real-Time Halal Audit Trail System (RT-HATS), and Halal Export Readiness Rating System (HERRS). **Conclusion**: The proposed framework strengthens compliance, builds transparency, and supports MSME participation in global halal trade. **Novelty/Originality of this article:** The novelty of this article lies in presenting a comprehensive, technology-enabled assurance ecosystem that shifts Indonesia's halal system from static certification toward dynamic, integrated, and globally competitive halal governance.

KEYWORDS: halal certification reform; halal supply chain management; integrated halal assurance system.

1. Introduction

Indonesia holds a strategic position in the global halal industry, supported by the world's largest Muslim population and the potential for a growing global halal market. The global halal market is estimated to reach USD 2 trillion and could reach USD 2.8 trillion in the next few years. The government has also established a legal framework through Law No. 33/2014 and its implementing regulations, requiring halal certification for all products in circulation. However, the current system is still based on point-based certification and manual inspection, so monitoring supply chain variability such as cross-contamination and changes in raw materials is still limited.

Digital technologies such as Internet of Things (IoT) and blockchain play a crucial role in strengthening the traceability and transparency of the halal supply chain. IoT creates five

Cite This Article:
Mahashofia, D., Kusumawati, F., Negara, L. P. A. (2025). Integrated halal assurance ecosystem (IHAE): The first step to integrate halal industry's supply chain with smart halal contract agreement (SHCA). *Journal of Economic Resilience and Sustainable Development, 2*(2), 77-94. https://doi.org/10.61511/ersud.v2i2.2025.2343

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key benefits, ranging from product tracking to real-time monitoring for halal certification (Nurhayati et al., 2021). Furthermore, technologies such as blockchain have been identified in 31% of studies as a key innovation in the halal supply chain, followed by IoT/RFID (11%). However, most studies are still partially focused and do not encompass an integrated ecosystem framework.

Various countries have also attempted to implement these technologies sectorally. Malaysia, for example, has a Halal Assurance System and halal logistics standards, the UAE is developing blockchain-based traceability for meat exports, and Thailand excels in science-based halal forensics. However, none of these includes a contractual network or real-time end-to-end oversight. To address the limitations of the still-partial halal assurance system in various countries, Indonesia has a significant opportunity through the innovation of the Integrated Halal Assurance Ecosystem (IHAE). This system will combine halal protocols, supply chain networks, smart contracts, and real-time audits based on technologies such as blockchain and IoT. In addition to strengthening product halal certification comprehensively, the IHAE innovation can also improve the export readiness of MSMEs through an objective assessment system (HERRS), which could potentially make Indonesia a global model for an integrated halal assurance system.

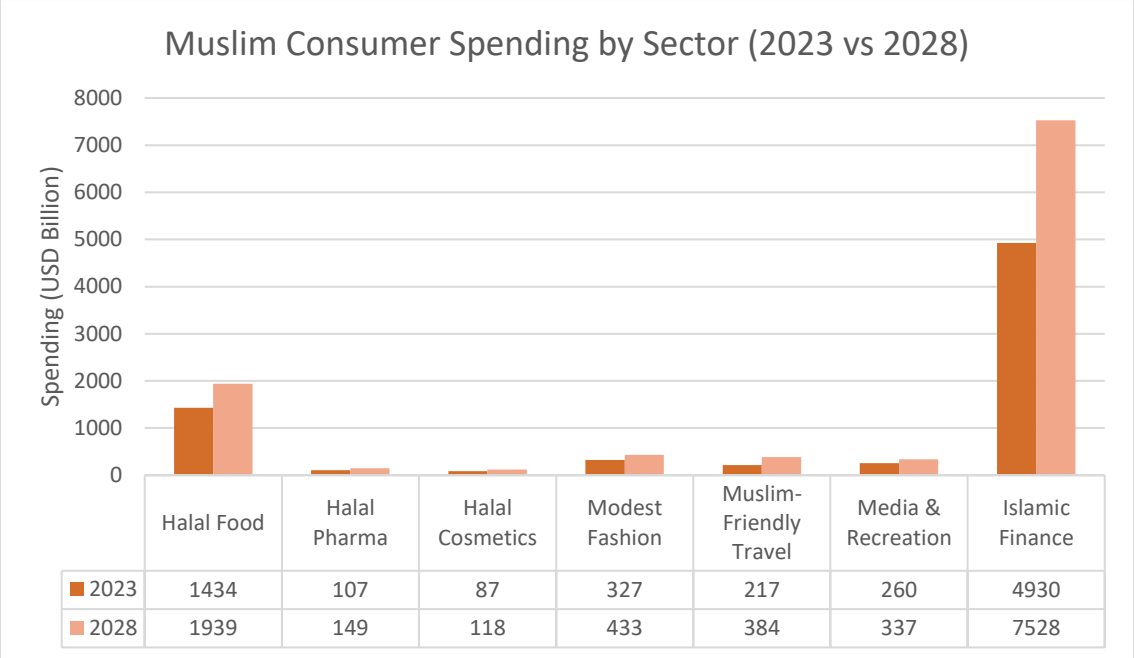

Fig. 1. Muslim consumer spending by sector (2023 vs 2020)
(DinarStandard & Salaam Gatewa, 2024)

The graph shows a projected significant growth in Muslim consumer spending across various halal sectors between 2023 and 2028, with halal food and Islamic finance dominating globally. This increase underscores the urgency of strengthening the halal assurance system, which is no longer merely administrative and pre-market, but must also be based on integrated processes and technology from upstream to downstream. Therefore, in this context, the development of the Integrated Halal Assurance Ecosystem (IHAE) is highly relevant, as it can address the challenges of traceability, transparency, and global market trust, particularly in strategic sectors such as food, pharmaceuticals, and cosmetics, which are experiencing rapid consumer spending growth. With a protocol-based approach, network, and digitalization of halal audits, IHAE can also strengthen Indonesia's position in the competitive, trillion-dollar global halal industry.

This situation opens opportunities for innovation in the Integrated Halal Assurance Ecosystem (IHAE). IHAE can expand the concept of traditional assurance systems through five components: halal assurance protocol (HAP), network (HAN), smart contract (SHCA), IoT + AI audit (RT-HATS), and export readiness assessment (HERRS). This model can

transform thdownstream andce paradigm into a digital, contractual, and proactive system, connected from upstream to downstream, and can provide data for targeted interventions for MSMEs and exporters.

An international study through five case studies shows that blockchain can enhance supply chain integration by highlighting various adoption challenges at the MSME level, such as costs and regulations (Ali et al., 2021). Furthermore, the combination of IoT and blockchain can also create data that is resistant to manipulation and ensures security, although user acceptance and technical maturity are major obstacles. Therefore, the IHAE innovation presents a comprehensive and contextual solution for Indonesia and can also serve as a potential model for an integrated global halal assurance system.

The development of the Integrated Halal Assurance Ecosystem (IHAE) in Indonesia is one of the strategic steps to strengthen the country's position in the global halal industry, which is worth trillions of dollars. However, in the current era of digitalization, the halal assurance system faces several technical and institutional challenges. The digital readiness of business actors, especially those in the micro, small, and medium enterprises (MSME) sector, is still low. Limitations in technological infrastructure, a lack of human resources with an understanding of technologies such as blockchain and the Internet of Things (IoT), and resistance to changing manual systems are major obstacles (Ali et al., 2021; Hendayani & Fernando, 2023). The readiness of a technology and the existence of public policies are also important determinants in the success of the halal chain digitalization system in developing countries such as Indonesia.

In addition, infrastructure limitations and high initial investment costs have also been serious obstacles to the adoption of blockchain and IoT systems in the halal supply chain. The installation of IoT sensors, the development of smart contracts, and the integration of digital audio systems also require large amounts of capital and are difficult for MSMEs to access (Ali et al., 2021). Therefore, research by Rahman et al. (2022) proposes a collaborative financing model through a shared technology platform based on partnerships between the government, certification agencies, and Islamic financial institutions to expand the participation of small businesses. In addition, it is also important to be able to integrate technology that is in accordance with several sharia principles. Permissioned blockchain systems have been deemed most appropriate for ensuring limited authorization, transparency in audit systems, and compliance with several halal principles in every digital transaction (Hassan et al., 2024). This approach has prevented data manipulation and can also maintain the authenticity of halal certification in a sustainable and effective manner in the future (Noor et al., 2023).

Halal certification institutions in many countries still rely on manual systems based on documents and physical inspections, so they tend to reject the adoption of digital technology that requires real-time monitoring and smart contract auditing (Jaffar & Musa, 2022). Nasir et al. (2023), through bibliometric analysis, found that research on halal supply chain management is still predominantly sectoral in nature, but is not yet integrated across chains, and has minimal focus on institutional reform. This condition also indicates the need for a comprehensive transformation that not only focuses on technological aspects but also institutional reform and increased digital literacy throughout the halal value chain. In this context, the IHAE system offers a comprehensive solution through the integration of the Halal Assurance Protocol (HAP), Halal Network (HAN), Smart Halal Contract Agreement (SHCA), Real-Time Halal Audit and Traceability System (RT-HATS), and Halal Export Readiness Rating System (HERRS).

Then, from a design perspective, the IHAE system can also be developed in a modular and gradual manner, starting with strategic sectors such as food, cosmetics, and pharmaceuticals, which can be some of the main contributors to global Muslim consumer spending (DinarStandard & Salaam Gatewa, 2024). This modular approach also allows for limited trials and flexible adaptation for MSMEs before the system is expanded nationally. Research (Hasan et al., 2023) explains that the permissioned blockchain architecture with a privacy layer has also provided a balance between the need for public transparency and the protection of trade secrets. Sensitive data can be stored using the off-chain feature, while

its hash can be stored in a blockchain trap as a form of unverifiable verification evidence. Meanwhile, IoT technology can serve to strengthen the halal audit system in real time through sensors that can detect temperature, humidity, chemicals, and indications of potential contamination (Khan et al., 2023).

A study has also shown that the integration of IoT with artificial intelligence (AI) and blockchain has created a halal traceability system that is resistant to manipulation and enables data-driven predictive analytics for automated auditing (Hashim et al., 2022). Thus, the traditional reactive halal system can also be transformed into a proactive and evidence-based system. Research Noor et al. (2023) emphasizes the importance of a data-driven governance approach to ensure halal integrity, while a study highlights that a digital system can strengthen global consumer confidence by reducing information asymmetry between producers and regulators (Rahman et al., 2022).

At the policy level, a study by Jaffar & Musa. (2022) emphasizes the importance of regulatory interoperability so that national halal data can be effectively integrated with existing international systems, such as those in accordance with OIC/SMIIC standards. Such harmonization is also crucial to avoid duplication of cross-border audits and to facilitate the export of halal products from Indonesia. Ultimately, the implementation of the IHAE system has the potential to bring significant economic and social impacts. Data transparency and automated audits can increase global market confidence in Indonesian halal products. Operational efficiency can be improved, the risk of potential contamination reduced, and long-term audit costs hopefully reduced. Furthermore, the system can empower MSMEs to enter the global supply chain through a data-based export readiness assessment system (HERRS). With integrated digital transformation and strong sharia compliance, Indonesia has the potential to become one of the pioneers of a transparent, efficient, and reliable global halal assurance model (Ali et al., 2021; Hendayani & Fernando, 2023; Nasir et al., 2023).

2. Methods

This study employs a qualitative descriptive research design to explore structural weaknesses in Indonesia's halal certification system. This approach provides a comprehensive description of the phenomenon in depth without hypothesis testing (Waruwu, 2024). The analysis draws primarily on secondary data sources, including national regulations (Law No. 33/2014, Law No. 6/2023, and their implementing regulations), government reports, international best practices in halal governance, and peer-reviewed academic literature.

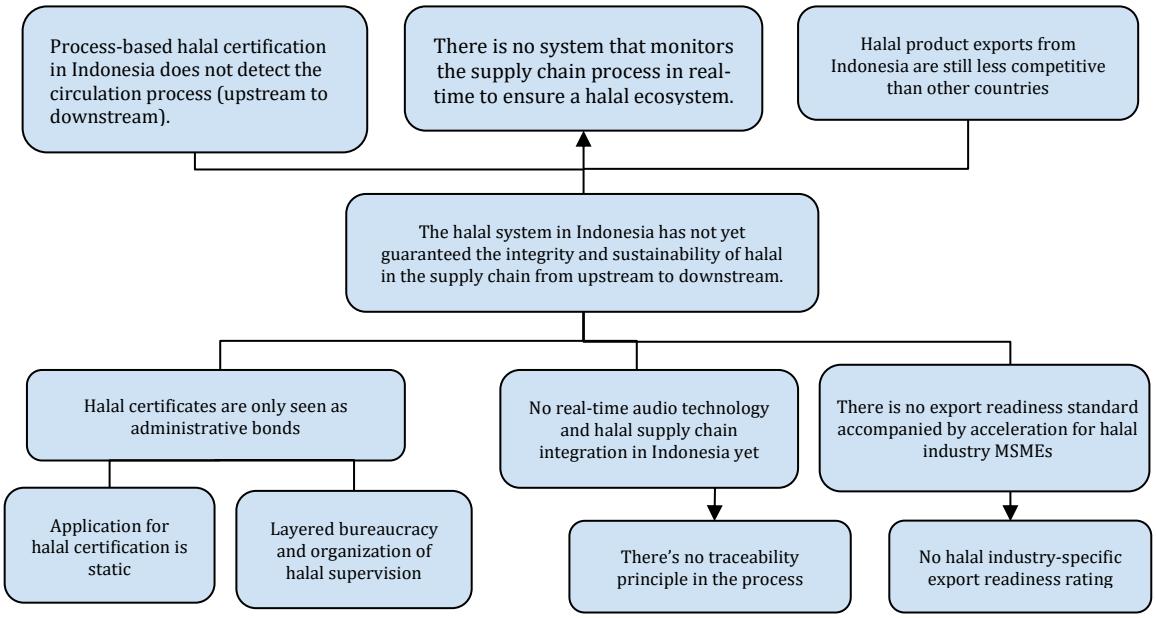

Fig. 2. Problem tree analysis of halal certification system in Indonesia

Three policy analysis tools were applied. Problem tree analysis was used to map the root causes, direct consequences, and systemic barriers within the current halal system. SWOT Analysis provided an evaluation of the internal strengths and weaknesses of Indonesian halal governance in relation to global opportunities and threats. PESTLE Analysis was conducted to assess external factors, including political commitment, economic potential, social awareness, technological infrastructure, legal harmonization, and environmental sustainability.

Rather than testing hypotheses, this methodological approach emphasizes conceptual synthesis, policy comparison, and framework design, enabling the formulation of the Integrated Halal Assurance Ecosystem (IHAE) as a scalable and adaptive solution. The stages in constructing the Problem Tree are quite simple. The first step begins by identifying and analyzing existing problems in the halal industry, then analyzing the impact of existing halal assurance policies to produce a tree-like diagram that focuses on the root of the problem, the cause of the problem, and the impact of the problem (Kasih et al., 2024).

3. Result and Discussion

3.1 Gaps in Indonesia's national halal assurance system

Since October 17, 2019, halal certification in Indonesia has shifted from being voluntary to mandatory for businesses (Faridah, 2019). Non-compliance may result in written warnings, administrative fines, or product withdrawal from the market (Naisabur & Putra, 2024). Yet, many businesses, especially MSMEs, still perceive halal certification merely as paperwork or branding, leading to low awareness and weak compliance with sharia requirements. With the passage of Law No. 6/2023, halal certificates in Indonesia are now permanent, eliminating the need for periodic renewal. While this eases participation, concerns remain over compliance, as Indonesia lacks a dynamic monitoring system to ensure continuous adherence to halal standards.

Currently, the halal certification framework relies on periodic audits and manual inspections as outlined in Law No. 33/2014, PP No. 31/2019, PP No. 39/2021, and PMA No. 26/2019. These audits are not real-time, nor do they leverage modern technologies such as IoT or blockchain. This creates compliance gaps, as monitoring remains limited to producers and does not fully cover supply chains (Hasanah & Fahruddin, 2021). For example, Halal Product Guarantee Agency/*Badan Penyelenggaran Jaminan Produk Halal* (BPJPH) audits of slaughterhouses occur only twice a year, leaving room for manipulation in between (Alamsyah et al., 2022). Without continuous monitoring, the system struggles to guarantee halal integrity across the value chain.

Research also highlights the lack of integration between supply chain management and technological solutions. While blockchain and IoT-based frameworks have been proposed (MDPI, 2023; Kurniawan et al., 2025), they remain unimplemented nationwide. MSMEs and restaurants still show moderate to low halal supply chain performance (Herlina et al., 2024; Ratnaningtyas et al., 2022). In the absence of real-time auditing standards and tech adoption, Indonesia's halal assurance system remains vulnerable to fraud and unable to keep pace with global supply chain complexity.

Another difference lies in export readiness. Despite a strong legal framework for halal certification, Indonesia lacks a dedicated system to assess halal businesses' preparedness for international markets. Existing regulations focus primarily on domestic certification procedures, without providing benchmarks for export logistics, digitalization, compliance documentation, or global market entry. The main cause was because there are alot of unexamined factors, like price, exposure, place, halal supply chain, and advertising (Fatmi et al., 2020). It is also made worse by the fact that the existing halal standard positively influences producers' internal operations but faces challenges like heterogeneity of standards and supply chain bottlenecks (Jailani, 2024).

Studies confirm that most Indonesian halal MSMEs lack structured export training and digital readiness (Effendi, 2023; Pujiono et al., 2018). While some have basic legal standing

and internal audits, there is no standardized "Halal Export Readiness Rating System" (HERRS) to classify and guide them toward global expansion (Abdoes Sjakoer et al., 2022). This leaves businesses without a roadmap for international growth and makes it harder for policymakers to identify which firms to support through incentives or export incubation. Therefore, reforming Indonesia's halal system requires more than administrative certification. It must also build a measurable, technology-enabled readiness framework to ensure continuous compliance and global competitiveness.

A descriptive analysis of Indonesia's halal policy framework reveals a significant disparity between formal regulations and the practical demands of the global halal market. Regulations such as Law No. 33 of 2014 and Government Regulation No. 39 of 2021 mandate halal certification for all products; however, the current approach remains predominantly reliant on point-based certification and manual inspections.

This administrative-centric model does not align with the complexity of modern cross-border halal supply chains, which involve heterogeneous actors, including farmers, manufacturers, distributors, and exporters (Rejeb et al., 2021). Within this context, Indonesia faces three critical weaknesses: the national halal auditing framework has not been designed to ensure continuous monitoring. Manual and periodic inspections, as stipulated in the current policy, are insufficiently responsive to risks such as cross-contamination and fraudulent certification practices across the supply chain (Alamsyah et al., 2022); Indonesia's halal supply chains remain under-digitalized. Limited adoption of advanced technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence (AI) constrains the system's ability to achieve traceability and process transparency, ultimately undermining Indonesia's credibility in the global halal market (Ali et al., 2021); Indonesia lacks standardized instruments to assess the export readiness of micro, small, and medium-sized enterprises (MSMEs) and industry players seeking to penetrate international markets. Consequently, despite the growing number of halal-certified products domestically, Indonesia's contribution to the global halal export value remains stagnant at below 5% (DinarStandard & Salaam Gatewa, 2024).

This unpreparedness is not without reason, especially since Indonesia's readiness for halal exports is determined not only by market potential but also by institutional strength, human resources, and infrastructure and policy support. Various studies and reports show that obstacles to the development of halal exports can be grouped into four main aspects: regulation and institutions, human resources and awareness, financial and technical constraints, and international competition.

The transfer of halal certification authority from the Indonesian Ulema Council/*Majelis Ulama Indonesia* (MUI) to the Halal Product Guarantee Agency/*Badan Penyelenggaran Jaminan Produk Halal* (BPJPH) has brought significant changes to the governance of certification. However, fragmented regulations and procedures that are not yet fully integrated have caused confusion and slowed down the implementation of the national halal policy (Sani, 2023). In addition, Indonesian halal certification is not yet widely recognized in the global market, so exporters need to obtain additional certification from their export destination countries to meet international standards (Fathoni, 2020).

Apart from normative issues, structural barriers arise from the limited number of halal auditors and the lack of economic incentives for small businesses. Malaysia, through the Malaysian Islamic Development Department/*Jabatan Kemajuan Islam Malaysia* (JAKIM) and the Halal Development Corporation (HDC), has successfully created a halal assurance system that is integrated with the sharia financing ecosystem and certified professional training. Meanwhile, in Indonesia, halal auditor training is sporadic and not yet connected to industry needs (Maulana et al., 2024). In Indonesia's case, this challenge is particularly felt by MSMEs, which often lack the technical capacity to meet halal standards. In addition, low public and business awareness of the importance of halal certification has resulted in low participation in the certification process (Budiyoko et al., 2022).

Cost barriers also exacerbate the situation, as the halal certification process can be costly, especially for MSMEs that do not yet have a standard documentation structure. The absence of a performance-based subsidy scheme or halal compliance grant discourages

business actors from updating their production systems. In addition, inadequate halal infrastructure and logistics, including transportation systems, supply chains, and quality control facilities, increase the risk of product contamination and reduce consumer confidence. Inter-agency coordination is still not optimal (Rizki et al., 2024). The Ministry of Religious Affairs, through Halal Product Guarantee Agency/*Badan Penyelenggara Jaminan Produk Halal* (BPJPH), National Committee for Sharia Economics and Finance/*Komite Nasional Ekonomi dan Keuangan Syariah* (KNEKS), the Ministry of Industry, and the Ministry of Cooperatives, still runs halal programs on a sectoral basis.

Furthermore, Indonesia also faces challenges from countries that have developed their halal ecosystems earlier, such as Malaysia and Thailand, which have more mature and internationally recognized certification standards (Hulwati et al., 2025). The advantages of these countries in terms of regulation, infrastructure, and halal branding have put Indonesia in a relatively disadvantaged position in the halal product export market. To address this, economic diplomacy and international cooperation strategies are needed to harmonize standards and promote Indonesian halal products in the global market. Thus, IHAE can become an integrative cross-institutional platform, connecting regulatory compliance, digital governance, and export facilitation in an integrated manner. IHAE is not only a technological solution but also a public governance instrument that can reduce institutional gaps and strengthen national synergy in halal supervision.

3.2 Integrated halal assurance ecosystem (IHAE)

To address the challenges outlined above, this study proposes the Integrated Halal Assurance Ecosystem (IHAE), an Industry 4.0-based innovation framework that integrates regulatory compliance, digitalization, and export readiness into a unified ecosystem. The development of IHAE is grounded in recent findings indicating that global halal assurance models have evolved towards digital contact points and real-time, data-driven audits (Rejeb et al., 2021). However, no existing framework has yet formalized such integration comprehensively within the Indonesian context. The strategic components of IHAE are summarized in Table 1.

Table 1. Strategic components of IHAE

IHAE Component	Core Function	Strategic Contribution
Halal Assurance Protocol (HAP)	Development of dynamic internal halal SOPs, mandatory for all industry actors	Enhances process-based shariah compliance and reduces reliance on manual audits
Halal Assurance Network (HAN)	Establishment of an integrated digital network among halal supply chain stakeholders	Facilitates connectivity between MSMEs, exporters, and regulators within a unified data ecosystem
Smart Halal Contract Agreement (SHCA)	Utilization of blockchain technology to create self-executing halal digital contracts	Reduces fraud risks, enhances credibility, and strengthens trust in global halal markets
Real-Time Halal Audit Trail System (RT-HATS)	Deployment of IoT and AI for continuous, real-time halal audits	Ensures traceability and responsiveness to potential halal violations across all production stages
Halal Export Readiness Rating System (HERRS)	Implementation of an objective scoring system for halal export readiness	Assist policymakers and investors in targeting interventions and incentives more precisely.

The Integrated Halal Assurance Ecosystem (IHAE) system is designed as a comprehensive framework that integrates various components of digital technology-based halal governance, with the aim of improving the efficiency, transparency, and credibility of Indonesia's halal industry in the global market. IHAE consists of five interconnected main components, namely the Halal Assurance Protocol (HAP), Halal Assurance Network (HAN), Smart Halal Contract Agreement (SHCA), Real-Time Halal Audit Trail System (RT-HATS), and Halal Export Readiness Rating System (HERRS). Each component does not function

independently, but rather synergistically to form an integrated halal governance ecosystem between industry players, regulators, and certification bodies.

3.2.1 Halal assurance protocol (HAP): Internal process standardization

The HAP component functions as a dynamic operational guide that serves as a standard operating procedure (SOP) for all halal industry players. Unlike conventional manual systems, HAP is designed to be regularly updated through an artificial intelligence (AI)-based smart audit module. The main function of HP is to ensure that all production processes, from raw material procurement to final distribution, are carried out in accordance with sharia principles and applicable halal regulations.

The implementation of HAP also strengthens process-based sharia compliance, which is compliance with halal standards based on processes, not just on the final product. Through the integration of a digital audio system, the certification process becomes more efficient, transparent, and can be monitored by regulators in real-time. HAP also reduces dependence on manual audits, which are often time-consuming and costly. Thus, HAP contributes directly to improving the efficiency of the national halal industry and strengthening the credibility of Indonesia's halal product assurance system in the eyes of the international community.

3.2.2 Halal assurance network (HAN): Digitalization of the halal supply chain

The HAN component aims to build digital connectivity across the halal supply chain, from raw material suppliers and certification bodies to exporters. Through a cloud ledger system, a form of distributed ledger technology that enables secure storage and updating of halal data, HAN ensures that every entity in the supply chain has access to the same and most up-to-date halal information.

HAN's strength lies in its ability to integrate cross-sector data, including food, pharmaceuticals, cosmetics, and logistics, into a single unified data ecosystem. With this system, regulators can comprehensively monitor the movement of halal ingredients and products and identify potential certification violations more quickly. HAN also opens opportunities for collaboration between MSMEs, large exporters, and government agencies in strengthening the data-driven halal industry ecosystem.

Beyond its technical functions, HAN has strategic value in promoting inter-country connectivity through cross-border halal data exchange. Through this network, Indonesia can establish cooperation with halal authorities from other countries such as Malaysia, Brunei, and Saudi Arabia, thereby expanding international recognition of the national halal certification system.

3.2.3 Smart halal contract agreement (SHCA): Contract digitalization and transaction transparency

The SHCA component uses blockchain technology to create digital contracts that can execute themselves (self-executing smart contracts). The application of this system enables the halal verification process at the transaction level to be automatic, transparent, and free from manipulation. For example, when raw material is certified halal by a registered institution, the system will automatically change its status in the ledger and activate a delivery contract with other parties also registered in the halal network.

Through SHCA, the risk of fraud and misuse of halal labels can be minimized because every step of the transaction is permanently recorded in the blockchain ledger. This system also strengthens the credibility of Indonesian exporters in the global market, as international buyers can verify the authenticity of certification data without having to wait for manual administrative processes. SHCA thus becomes an important pillar in increasing trust in the international halal market and supporting Indonesia's reputation as a credible supplier of halal products.

3.2.4 Real-time halal audit trail system (RT-HATS): IoT-based production monitoring

RT-HATS is a monitoring system that uses Internet of Things (IoT) and AI technology to conduct continuous, real-time halal audits. This system monitors all stages of production in the halal industry, especially in high-risk sectors such as food, pharmaceuticals, and cosmetics. Each IoT device installed on the production line automatically sends data to a central server, which is then verified by a halal audit algorithm.

The main advantage of RT-HATS is its ability to detect potential certification violations early on. If the system finds anomalies, such as contamination with non-halal ingredients or procedural deviations, an alert is automatically sent to auditors and regulators. With this mechanism, violations can be handled quickly and efficiently, preventing economic and reputational losses. Furthermore, RT-HATS also strengthens global consumer confidence in Indonesian halal products because its audit system is based on actual data, not just periodic reports. In the context of exports, RT-HATS data can be integrated with international logistics tracking systems to ensure that the halal supply chain is maintained until it reaches the end consumer.

3.2.5 Halal export readiness rating system (HERRS): Measuring export readiness

HERRS is an evaluative component that uses data from RT-HATS, HAN, and HAP to measure a company's level of halal export readiness. This system works by applying an assessment model based on five main dimensions: compliance with halal standards, digitization of production processes, logistics and distribution readiness, completeness of certification documentation, and market competitiveness.

Through a quantitative and qualitative approach, HERRS provides an objective score for the halal performance of exporters. This score serves as a basis for policymakers in determining intervention priorities, providing incentives, and mentoring programs for halal industry players. With this system in place, the government can target more focused support, such as certification cost subsidies, supply chain digitalization training, or export promotion facilitation to potential markets. In addition to serving as a policy tool, HERRS also assists investors and financial institutions in conducting risk assessments. Companies with high scores are considered to have good halal governance and are potentially more competitive in the global market, making them attractive for funding. Thus, HERRS not only strengthens halal export readiness but also creates an investment ecosystem that supports national halal economic growth.

3.2.6 Synergy between components and strategic contribution

The integration of all components in IHAE creates a sustainable and mutually reinforcing data cycle. HAP ensures internal compliance at the industry level, HAN provides data connectivity between supply chain actors, SHCA guarantees the validity of halal transactions, RT-HATS conducts continuous monitoring, and HERRS measures performance and export readiness. This synergy forms a governance ecosystem that focuses not only on halal certification but also on increasing the competitiveness and sustainability of the national halal economy. With IHAE, Indonesia's halal system is transforming from a mere compliance mechanism into a strategic economic development instrument.

Furthermore, cross-component data integration enables evidence-based policy making, accelerates the certification process, and increases transparency throughout the supply chain. The government can use aggregate data from HERRS to map export readiness by sector and region, while businesses can utilize digital audit results from RT-HATS to improve production processes. Overall, IHAE demonstrates how the digitization of halal governance can be key for Indonesia in strengthening its position as a global halal economic center. With consistent implementation, adaptive regulatory support, and broad international cooperation, IHAE has the potential to bridge the gap between domestic

certification and global recognition, creating an inclusive, transparent, and competitive Indonesian halal ecosystem.

The success of IHAE implementation is not only determined by the strength of its system design, but also heavily depends on the active and collaborative involvement of various cross-sector stakeholders. Each actor has complementary functions, ranging from regulation, fatwas, technical guidance, to technology development and export facilitation. Therefore, mapping institutional roles is crucial to ensure that this halal assurance ecosystem runs in a coordinated, effective, and sustainable manner.

First, the Ministry of Industry/*Kementerian Perindustrian* (Kemenperin) acts as the main driver in encouraging the adoption of IHAE in the industrial sector. Kemenperin can link the industry's level of compliance with IHAE protocols to access to fiscal incentives, such as tax breaks, financing facilities, and priority in the national halal industry facilitation program. This incentive-based approach not only accelerates the adoption of the system but also creates an economic incentive for industry players to strengthen halal integrity in their production processes.

Meanwhile, the National Research and Innovation Agency/*Badan Riset dan Inovasi Nasional* (BRIN) together with technology startups have a strategic role in digital development and innovation. They are responsible for designing and operating the main technological components of IHAE, such as the blockchain platform for the Smart Halal Contract Agreement (SHCA), the Internet of Things (IoT) system for the Real-Time Halal Audit Trail System (RT-HATS), and the big data analytics system for the Halal Export Readiness Rating System (HERRS). This collaboration between research institutions and the private sector ensures that Indonesia's halal ecosystem has a technological foundation that is up-to-date, secure, and adaptable to global market needs.

Externally, the Ministry of Foreign Affairs/*Kementerian Luar Negeri* (Kemenlu) and the Ministry of Trade/*Kementerian Perdagangan* (Kemendag) play a role in halal economic diplomacy and international trade promotion. These two institutions can integrate IHAE actors into the national export catalog and facilitate access to global markets through trade fairs, bilateral cooperation agreements, and international halal forums. This diplomatic role is important to expand recognition of Indonesia's halal certification system and strengthen the position of national halal products in the global supply chain. Thus, the halal diplomacy strategy is an integral part of Indonesia's efforts to gain international recognition for the IHAE system and expand the halal export market.

In addition to government agencies and technology innovators, halal industry associations and MSME actors also have an important position as the spearhead of IHAE implementation in the field. They play a role in the application of the Halal Assurance Protocol (HAP), improving human resource competencies, and disseminating the IHAE system at the grassroots level. Through technical assistance, supply chain digitization training, and the formation of local halal communities, industry associations can help accelerate business actors' adaptation to the IHAE system, especially in sectors that do not yet have adequate digital capacity.

Overall, synergy between the government, research institutions, industry players, and technology partners is key to the successful implementation of IHAE. The Ministry of Industry ensures the effective adoption of the system at the industry level through policies and incentives; BRIN and technology startups guarantee the sustainability of digital innovation; the Ministry of Foreign Affairs and the Ministry of Trade strengthen global networks and market recognition, while associations and MSMEs ensure the inclusiveness of implementation in the field. This collaboration forms a multi-level governance system that allows IHAE to develop not only as a digital halal audit system, but also as an integrated, adaptive, and globally competitive halal industry governance ecosystem.

3.3 PESTEL analysis

It is also essential to map the external dynamics that influence the broader implementation of the proposed policy. A PESTLE analysis was conducted to evaluate

macro-level factors affecting the sustainability and scalability of the Integrated Halal Assurance Ecosystem (IHAE) within the context of national economic development and global integration, as outlined below.

Firstly, politics. Strong government commitment to strengthening the Islamic economy through institutions such as National Committee for Sharia Economics and Finance/*Komite Nasional Ekonomi dan Keuangan Syariah* (KNEKS) and Halal Product Guarantee Agency/*Badan Penyelenggara Jaminan Produk Halal* (BPJPH) provides a significant foundation for political support of IHAE. However, regulatory consistency across agencies and policy continuity across political cycles remain potential challenges. Secondly, economics. IHAE supports the integration of micro, small, and medium enterprises (MSMEs) into halal export markets and is expected to increase the sector's contribution to GDP and job creation. Nonetheless, the initial costs of digital system implementation and limited access to sharia-compliant financing for MSMEs pose notable barriers.

Thirdly, Social. Rising public awareness of halal consumption and global trends toward halal products create significant opportunities. Yet, gaps in halal literacy and the low level of digital readiness among business actors, particularly MSMEs, may slow adoption. In terms of technology, the availability of digital infrastructure (IoT, blockchain, and artificial intelligence) and the involvement of national technology startups open opportunities for accelerating halal system transformation. The main challenges include uneven access to technology and the need to enhance digital skills capacity in regional areas.

Then, the legal foundation for IHAE is relatively strong, referencing Law No. 33/2014 and Government Regulation No. 39/2021. However, further harmonization of derivative regulations across ministries and alignment between MUI fatwas and digital contract mechanisms are critical to prevent overlapping jurisdictions.

Lastly, the environment. IHAE has the potential to foster a cleaner and more transparent halal supply chain, particularly in the food and pharmaceutical sectors. Still, effective monitoring of production waste and the integration of environmentally friendly logistics into the halal audit system remain necessary for sustainability.

In the long term, political aspects need to be directed towards the formation of a National Halal Digital Council (NHDC) that ensures policy consistency across government terms. From an economic perspective, IHAE can be integrated with the Halal Industry Masterplan 2045, making Indonesia the main hub for halal exports in ASEAN. Socially, increasing halal literacy among the public through vocational education curricula and digital public campaigns is key to accelerating the adoption of the IHAE system. Technological factors require the development of a national Halal Data Interchange to be interoperable with the Malaysian and Brunei systems, supporting mutual recognition arrangements (MRAs) at the ASEAN level.

The legal aspect must be directed towards the formation of Lex Halal Digitalis, which is a derivative regulation that legitimizes blockchain-based smart contracts within the framework of Islamic and national law. Meanwhile, from an environmental perspective, the integration of green halal logistics and sustainable production principles in digital halal audits will strengthen Indonesia's reputation in global markets that increasingly demand sustainability.

3.4 SWOT (strength, weakness, opportunity, threat) analysis

A SWOT analysis of the Integrated Halal Assurance Ecosystem (IHAE) shows the strategic position of this ecosystem in strengthening the governance of Indonesia's halal industry amid global dynamics. In terms of strengths, IHAE has a major advantage in its process-based halal system, rather than just the final product. This approach enables comprehensive oversight of the production chain through digital modules such as AI smart audit and IoT-based monitoring in the Real-Time Halal Audit Trail System (RT-HATS). In addition, the application of blockchain technology in the Smart Halal Contract Agreement (SHCA) strengthens transaction transparency and prevents falsification of halal certification data. Institutional support from agencies such as Halal Product Guarantee

Agency/*Badan Penyelenggara Jaminan Produk Halal* (BPJPH), National Committee for Sharia Economics and Finance/*Komite Nasional Ekonomi dan Keuangan Syariah* (KNEKS), Ministry of Industry/*Kementerian Perindustrian* (Kemenperin), and Indonesian Ulema Council/*Majelis Ulama Indonesia* (MUI) further strengthens the legitimacy of this system as part of the national transformation towards the digitization of the halal industry. Another advantage lies in the HERRS assessment system, which provides objective assurance of halal export readiness based on measurable data.

However, there are several weaknesses that still limit the optimization of IHAE implementation. One of the main obstacles is the low level of digitization among small and medium-sized enterprises (SMEs). Many SMEs do not yet have the technical capabilities or adequate digital infrastructure to integrate blockchain, IoT, or big data analytics-based systems. In addition, the readiness of human resources in the field of halal technology is still limited, so that the implementation of digital systems often requires intensive assistance. The limitations of interoperability between national systems and international standards are also a challenge, because Indonesian halal data is not yet fully connected to the global certification network. This has implications for the low level of trust in the domestic halal system in foreign markets and potential export barriers for IHAE actors.

In terms of opportunities, the prospects for IHAE development are enormous, given that the global halal market is worth more than USD 2.8 trillion and continues to experience significant growth. This opportunity is reinforced by the increasing demand for halal products not only in Muslim-majority countries but also in non-Muslim markets that are beginning to pay attention to ethical aspects and production quality. In addition, the direction of national policy that emphasizes strengthening the halal industry through the digitization of MSMEs is a strategic momentum for the development of IHAE. The digital transformation program, combined with the support of research institutions and technology startups, provides ample room for innovation in halal systems based on AI, blockchain, and big data. Not only that, international cooperation in the field of cross-border halal verification also opens opportunities for IHAE to be recognized as a digital halal certification model that is compatible with global systems.

However, threats still need to be anticipated so that the development of IHAE is not hampered by external factors or structural weaknesses. The biggest challenge is the lack of harmonization of halal standards at the global level, which means that Indonesian halal certification is not automatically recognized by foreign trading partners. This lack of synchronization can create technical barriers to trade, especially for products targeting export markets in the Middle East, the European Union, or South Asia. In addition, the risk of data leaks and cybersecurity issues is also increasing along with the growing dependence on digital systems. From an institutional perspective, coordination between government agencies still needs to be strengthened so that the supervision and enforcement of halal standards can be carried out effectively. If this coordination is weak, the potential for policy duplication and bureaucratic inefficiency could hamper the implementation of IHAE at the national level.

Overall, the SWOT analysis results show that IHAE has great strategic potential to make Indonesia the center of the global halal economy. Its successful implementation depends on the ability of the government and stakeholders to leverage technological strengths and global market opportunities, while overcoming internal challenges such as the digital divide, standard harmonization, and inter-agency governance. With strengthened regulations, digital infrastructure support, and increased human resource capacity, IHAE can develop into a halal ecosystem that not only meets national standards but is also competitive at the international level.

3.5 Positioning of IHAE within the global research landscape

This study advances the existing body of literature by extending prior findings and offering a distinct novelty through a systemic and integrative approach. For example, Ali et al. (2021) demonstrate that the implementation of blockchain technology can significantly

enhance the integrity of halal supply chains. However, their study highlights that widespread adoption remains limited due to high implementation costs and technological constraints, particularly among micro, small, and medium-sized enterprises (MSMEs). Meanwhile, Rejeb et al. (2021) emphasize the potential of the Internet of Things (IoT) to enable real-time traceability within halal value chains, but their research does not integrate broader aspects such as regulatory frameworks and export readiness mechanisms.

In contrast to these earlier studies, the primary contribution of this research lies in its multi-layer integration of key elements within the halal assurance ecosystem. While previous models tend to focus on a single dimension such as blockchain-based traceability or standalone regulatory certification, the Integrated Halal Assurance Ecosystem (IHAE) combines digital technologies, policy frameworks, and export readiness assessment instruments into a unified operational model. This comprehensive integration allows IHAE to address end-to-end challenges across halal supply chains, from production to global market penetration, positioning it beyond the scope of existing frameworks that are often fragmented and sectoral in nature.

Another aspect of novelty lies in the adaptive and scalable design of IHAE. Unlike prior models, which are often constrained to specific industries or organizational contexts, IHAE is structured to accommodate a wide spectrum of actors within the halal ecosystem. It is designed to be applicable not only to resource-constrained MSMEs but also to large multinational corporations managing cross-border halal supply chains. This adaptability ensures that the framework remains relevant in diverse operational contexts, effectively bridging the gap between localized practices and the demands of the global halal economy.

Furthermore, this research introduces evidence-based policy innovation through the development of the Halal Export Readiness Rating System (HERRS). By providing an objective and structured tool to measure the export readiness of industry players, HERRS empowers policymakers, regulators, and investors to design targeted interventions, allocate incentives, and develop capacity-building programs with greater precision. This integration of policy mechanisms into the technological framework distinguishes IHAE from earlier research, which largely focuses on technological or regulatory aspects in isolation.

Through these contributions, IHAE emerges as more than a technological framework; it represents a comprehensive governance model for halal industries in the digital era. Its multidimensional approach, combining technology, policy, and institutional mechanisms, enables it to serve as both a theoretical advancement and a strategic policy instrument. Moreover, the replicability and scalability of IHAE offers broader applicability for other countries seeking to enhance their competitiveness within the global halal economy.

IHAE also has the potential to serve as a model for the establishment of the ASEAN Halal Data Interchange (AHDI), which facilitates the exchange of halal data across countries. Thus, this research not only contributes theoretically to Indonesia's halal economic diplomacy. Methodologically, this approach reinforces the policy-based innovation paradigm, whereby technological development is driven by public policy needs rather than solely by the industrial sector. This approach opens opportunities for research collaboration between regulators, universities, and halal technology startups, accelerating the process of co-creation of policy innovation at the regional level.

4. Conclusions

Indonesia has a strategic opportunity to become a global hub for the halal industry. However, the existing halal assurance system remains administrative and fragmented, thus failing to address the complexities of the modern halal supply chain. The Integrated Halal Assurance Ecosystem (IHAE) initiative offers a comprehensive policy framework by integrating halal protocols, digital supply chain networks, smart contracts, technology-based real-time audits, and an export readiness assessment system.

The implementation of the IHAE not only addresses regulatory gaps and traceability challenges but also strengthens the competitiveness of MSMEs, improves export readiness, and encourages the growth of an inclusive, adaptive, and sustainable halal industry. With

cross-sectoral institutional support and the use of digital technology, the IHAE has the potential to position Indonesia as a global pioneer in process- and technology-based halal assurance systems.

Therefore, going forward, the success of the IHAE implementation depends heavily on collaboration between the government, certification bodies, businesses, and technology innovators. This synergy across various sectors will determine whether Indonesia can become not only the largest consumer of halal products but also a major producer with competitive global standards. Thus, the IHAE can be a transformative step toward a more trusted, inclusive, and sustainable development-oriented halal ecosystem.

To realize the transformation towards a well-integrated halal assurance system, the development of the Integrated Halal Assurance Ecosystem (IHAE) needs to be directed towards strengthening digital infrastructure and institutional synergy across sectors. The implementation of technologies such as blockchain systems, the Internet of Things (IoT), and artificial intelligence (AI) can build a strong foundation for a halal, transparent, and efficient monitoring system. Through a digital integration system, various activities in the halal supply chain, from raw material production, processing, distribution, to final consumption, can be monitored in real-time. Thus, the halal certification process is no longer merely administrative in nature, but can be transformed into a data-driven, automated, and accountable system.

The success of the IHAE system implementation is also highly dependent on the readiness of human resources and collaboration between institutions. Many micro, small, and medium enterprises (MSMEs) still face difficulties in meeting global halal standards, both in terms of digital literacy and understanding of the relevant regulations. Therefore, there is a need for capacity building programs and ongoing technical assistance so that MSMEs can adapt to the digital certification system and utilize technology to improve production efficiency. The government can play a key role as a facilitator through fiscal incentive policies, sharia-based financing facilities, and data integration between ministries and institutions related to halal product certification.

In addition, the implementation of the IHAE system can also be a strategic instrument in strengthening national export competitiveness. This system is not only to ensure compliance with domestic halal standards, but also to bridge harmonization with international standards set by several global institutions such as the OIC and SMIIC. Thus, Indonesian halal products have the potential to penetrate a wider market with a high level of trust from consumers globally.

Furthermore, the role of the IHAE system also has the potential to encourage the formation of an inclusive and sustainable halal ecosystem. Through a data-driven and transparent approach, the system can also provide protection to many consumers, business certainty for producers, and efficiency for several certification bodies. Additionally, through the implementation of automated and AI-based audits, it is hoped that this will reduce the risk of data manipulation and accelerate the certification process without compromising the principles of halal integrity.

Ultimately, the success of the IHAE system will depend on the collective will of all stakeholders from the government, industry, certification agencies, and technology innovators to work collaboratively and effectively in the future. Furthermore, if implemented consistently and comprehensively, the IHAE system will not only strengthen Indonesia's position in the global halal market but also make it one of the leading models in the development of a more modern, adaptive, and sustainability-oriented global halal assurance system in the future.

Acknowledgement

The authors express their gratitude to the reviewers for their valuable and constructive feedback on this article.

Author Contribution
D.M., F.K., L.P.A.N., contributed to the literature search, interpretation, writing, and proofreading of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding
This research did not use external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The authors declare no conflict of interest.

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