

# Digital Governance and Fraud Risk Management in SIHALAL-Based Halal Certification in Indonesia: Towards a Sharia-Compliant Information System Framework and Artificial Intelligence (AI)-Assisted Verification

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## Abstract

This study examines the governance gaps of the SIHALAL platform and investigates the risks of *moral hazard* and *fraud* in Indonesia's self-declared halal certification scheme. This study uses an explanatory sequential mixed-methods approach, analyzing survey data from 107 MSMEs assisted by the Halal Center and BPJPH partners, as well as qualitative data from in-depth interviews with internal stakeholders, senior information technology auditors, and halal experts. Quantitative analysis was conducted using descriptive statistics and the Spearman correlation test, while qualitative data were analyzed using the Miles interactive model. Huberman. The results of the study indicate that information asymmetry and low digital literacy are associated with increased perceptions of system vulnerability, limited verification processes, and a high risk of data manipulation. This finding is supported by a strong Spearman correlation between low digital literacy and perceived *fraud risk* ( $\rho = 0.624$ ;  $p < 0.001$ ). This relationship shows a statistical association and cannot be interpreted as causal. Based on the integration of quantitative and qualitative findings, the study formulated a Shariah-Compliant Information Systems Framework that incorporates digital governance informed by COBIT 2019, Agency Theory, the *Fraud Triangle*, and *Maqashid Syariah*. The framework recommends implementing digital control mechanisms in including geotagging, digital timestamps, AI-based image verification, and audit trails, as potential approaches to strengthen data integrity, mitigate fraud risk, and improve the alignment of halal certification governance with *Maqashid Syariah*.

*Keywords:* Halal certification; SIHALAL; Father manages IT; Fraud prevention; Self-declare scheme; Maqashid Shariah.

Received: 9 April 2026

Revised: 7 June 2026

Published: 30 June 2026

## 1. Introduction

Law Number 33 of 2014 concerning Halal Product Assurance (UU JPH) has transformed Indonesia's national market system from a voluntary to a mandatory halal certification system for all products (Dian Luthviati & Jenvitchuwong, 2021). To accelerate the implementation of this policy, the Halal Product Assurance Agency (BPJPH) introduced a *self-declaration certification scheme* that relies on independent declarations from business actors as the basis for product halal legality (Isabella & Sari, 2023). The subsequent verification process is carried out by Halal Product Process Facilitators (PPH) through the integrated digital system SIHALAL (Rachmaniah et al., 2023). This approach accelerates certification for millions of micro, small, and medium enterprises (MSMEs). However, this acceleration without adequate oversight of information systems can pose risks in digital governance. A survey of 107 MSMEs assisted by Halal Center partners showed that 71.03% of respondents were still in the halal certification process. These findings are consistent with a report (Umi Cholifah et al., 2026), which noted a 73% technology adoption failure rate among SMEs due to various implementation constraints. This indicates that low technology adoption remains a common

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challenge, leaving many SMEs still in the transition phase toward using more mature technologies. Identified barriers include delays in document verification (25.23% of cases) and limited quality of assistance (24.30% of cases). Furthermore, 27% of surveyed SMEs were unaware of certification obligations for the 2024–2025 period, and their average understanding of certification procedures was only 3.42 out of 5.00. The level of satisfaction with BPJPH services was also only 3.53 out of 5.00, indicating a gap between expectations and the realization of digital public services. These findings are consistent with the results of a multidimensional investigation by Fauziah et al. (2026), which identified that the gap between the level of service importance expected by customers and the actual performance of Indonesian halal certification services is a structural issue that impacts SME trust and compliance with the formal certification system. In the current study, the research data were obtained through a survey of 107 halal SMEs in Indonesia selected using purposive sampling. The criteria were that businesses already had or were applying for halal certification and were using digital technology in their businesses. This approach was used to gain a clearer picture of the readiness and implementation of technology to support compliance with halal standards.

Reliance on data uploaded by PPH facilitators without adequate independent verification can create information asymmetry and moral hazard, particularly in quantitative, target-based incentive systems, which may encourage document manipulation and misuse, thereby compromising the integrity of the halal certification process. (Pratama, 2024). Interviews with BPJPH staff and halal experts also indicate that oversight of digital file integrity remains a major weakness in the current certification ecosystem (Primary Interview Data, 2025). From an Islamic economic law perspective, digital data manipulation in the halal certification system can undermine the integrity of the halal product assurance system and hinder the achievement of the objectives of Maqashid Syariah in safeguarding religion (Hifdz al-Din) and protecting consumers (Hifdz al-Nafs) (Syuhada, 2023). The integration of Maqashid Syariah in this study refers not only to classical interpretations but is also supported by an integration framework in digital governance. (Mohamad Puad & Asep Saepul Hamdi, 2025). This framework offers a more relevant operational framework for digital systems and ethical governance, providing a stronger conceptual basis for explaining technology's role in halal compliance and the halal industry's sustainability. To strengthen the argument about weak digital controls, this research could be supported by recent empirical findings on the success or failure of digital halal technology adoption in MSMEs, providing a stronger benchmark for interpreting the research results.

Agency Theory and the Fraud Triangle explain how information asymmetry, weak controls, and behavioral incentives can increase the risk of moral hazard in digital certification systems. (Pratiwi, 2026). However, this study does not intend to establish a direct causal relationship between these factors. This theoretical perspective is used as an analytical tool to examine the relationships among digital governance vulnerabilities, MSME digital literacy, and perceived fraud risk in the SIHALAL ecosystem. Therefore, empirical findings should be viewed as indicative of a statistical relationship, not as a definitive causal effect. (Maier et al., 2023).

Digitalization in halal certification and information technology governance has been frequently discussed, but significant gaps remain in preventing *internal fraud* in micro-scale schemes. Previous studies on digital halal supply chains, such as those by (Umi Cholifah et al., 2026), typically focused on macro logistics or *blockchain adoption* in large companies. As a result, administrative data manipulation and *moral hazard risks* in micro-certification have received little attention. Masitah et al. found that although independent halal certification has been introduced to assist Indonesian MSMEs via digital platforms such as SIHALAL, concerns remain about potential misuse and fraud. This highlights the need for stronger preventative measures. While research into halal technology continues to grow, empirical evidence on its effectiveness in SMEs remains limited. A survey of 2,222 micro- and small-business owners in Indonesia found that adoption of digital technology in this sector remains low. This indicates a gap between concept development and practical implementation, as reported in ScienceDirect. These findings underscore the need for empirical research to understand the factors influencing the successful implementation of technology to support compliance with halal standards. Furthermore, weak oversight of electronic system administrators and the low capacity of supervisory institutions are also at the root of the broader digital data governance problem in Indonesia, as demonstrated in a comparative study on digital sovereignty, which assessed that the national data protection framework remains normative and has not been fully implemented in supervisory practice. (Rahayudin Rahayudin et al., 2025). This context reinforces the urgency of strengthening digital control mechanisms on public platforms such as SIHALAL to maintain data integrity and accountability in verification.

A systematic literature review by Cagigas et al. (2021) shows that research on blockchain in public services predominantly focuses on its technological features and its potential to enhance transparency and governance. However, this research has not sufficiently addressed agent-level risks or provided robust empirical validation of data security and internal fraud in self-declaration schemes. Furthermore, the comprehensive review of public-sector digitization by Latupeirissa et al. (2024) and the cybersecurity review by Mijwil et al. (2023) focus primarily on general public service

delivery and external cyber threats, without addressing the internal moral hazard posed by verification agents in faith-based certification. While previous studies have advocated the use of AI and machine learning for fraud detection, existing approaches still suffer from numerous limitations, such as recall, scalability, complexity, precision, and accuracy, according to a review by L.K. Vishwamitra and Vishakha D. Akhare. Research on the risks of data manipulation in self-declared MSME schemes remains very limited. There is also a gap in the literature regarding risk analysis and digital governance processes in platforms such as SIHALAL, as well as the integration of the IT Governance Framework (COBIT 2019) with Maqashid Syariah for fraud mitigation, including the design of preventive technical requirements in SIHALAL development (Sazelin Arif, 2024) (Qanita et al., 2024). This study aims to fill this gap by developing a *Shariah-Compliant Digital Governance Framework* that combines COBIT 2019, *Agency Theory*, and Maqashid Syariah, and by designing features such as geotagging, digital timestamps, and AI-based image verification. To strengthen the argument about weak digital controls, this study also requires recent empirical evidence on the failure rate of digital halal technology adoption in SMEs so that the results can be interpreted more clearly.

This study identifies three main issues: (1) the vulnerability of the digital governance process on the current BPJPH *self-declared* halal certification platform ; (2) factors related to moral hazard risk according to *Agency Theory* and *Maqashid Syariah*; and (3) the design of an effective *Shariah-Compliant Digital Governance Framework Model to mitigate fraud risks in the scheme*. The objectives of this study are: (1) to identify and map SIHALAL digital governance risks through COBIT 2019-based process vulnerability analysis; (2) to analyze moral hazard risk factors and patterns based on the integration of *Agency Theory* and *Maqashid Syariah*; and (3) to formulate a *Shariah-Compliant Digital Governance Framework* model as a *fraud mitigation strategy* that BPJPH and LPH can implement. Theoretically, this study develops an interdisciplinary approach by combining the *IT Governance Framework* (COBIT 2019) with contemporary sharia economic law in the context of micro-scale halal certification. This topic has rarely been empirically tested in Indonesia. (Dawam et al., 2023). Furthermore, the need for empirical studies is increasingly pressing, as the adoption of digital halal technology in SMEs continues to face numerous obstacles. Further research is needed to understand the factors influencing its implementation. In practical terms, the results of this study provide strategic recommendations and a technological blueprint for BPJPH and LPH to strengthen the digital verification quality control system without hindering certification growth. Draft functional requirements for the *Geotagging*, *Timestamp*, and *AI Image Verification* modules have also been generated for consideration as new features in SIHALAL.

Many recent studies have proposed blockchain integration to enhance the transparency and reliability of halal systems. A comprehensive bibliometric review (Lahmar & Al Qaruty, 2026) confirms that although blockchain and AI have both received significant attention in the halal supply chain literature, the application of AI for document verification and anomaly detection offers greater implementation scalability in the MSME context than blockchain, which requires a more complex network infrastructure. Therefore, this study adopted an AI-based approach to support the automation of verification and decision-making processes. At the same time, blockchain serves as an enabling technology that strengthens trust and traceability within the system.

This study does not test a causal model. However, it aims to identify governance vulnerabilities, examine their relationship to perceived fraud risk, and formulate a governance framework to mitigate risk in the SIHALAL ecosystem. The empirical part of this study is designed to find statistically significant relationships and governance patterns within the SIHALAL certification ecosystem. The study by Machado and Gartner suggests that *Agency Theory* and the *Fraud Triangle* are used to explain the moral hazard mechanism theoretically. However, the cross-sectional design and correlational analysis in the study do not permit causal inference. Therefore, these findings should be understood as associative evidence to inform the development of a *Sharia-Compliant Information System Framework* for mitigating fraud risk.

The novelty of this research does not lie in the use of technologies such as geotagging, *digital timestamps*, or AI, as these technologies are already widely used in *fraud prevention* and digital verification systems. The main innovation of this research is the development of a *Shariah-Compliant Information Systems Framework* that combines COBIT 2019 governance principles, *Agency Theory*, the *Fraud Triangle*, *Maqashid Syariah*, and digital control mechanisms in *Self-Declaration-based halal certification*. This integration results in a governance framework and information system that simultaneously considers the technical aspects of digital control, agency risks, fraud prevention, and compliance with Islamic economic law principles. Unlike previous research that discussed IT governance, AI-based *fraud detection*, or the digitalization of halal certification separately, this research offers an integrative approach that connects digital governance, *fraud risk management*, and Maqashid Syariah values within a single conceptual framework to strengthen the integrity of digital halal certification. Thus, the main contribution of this research lies in the integration of concepts and governance, not in the development of new technologies.

## 2. Literature Review

Digital governance in public services encompasses accountability structures, decision-making rights, and rules for the use of information technology to ensure the achievement of organizational goals in a transparent and accountable manner. COBIT 2019 is frequently used to assess IT governance, focusing on stakeholder needs and establishing measurable objectives (Amore et al., 2023). The literature indicates that successful technology implementation also depends heavily on organizational readiness and external environmental support, not just on the framework used. In halal certification, BPJPH manages SIHALAL as a public digital platform to support the certification process. (Magfiratun & Awaludin, 2024). This study uses COBIT 2019 to assess SIHALAL's business process controls, specifically in the APO and DSS domains, to identify potential control gaps that could be exploited for data manipulation. Previous research has shown that failures in digital governance in the public sector can create opportunities for systemic internal fraud. In addition to drawing on theory, this study considers relevant empirical findings to better contextualize the analysis of SIHALAL. Recent studies have shown that SIHALAL is now a strategic part of Indonesia's digital halal ecosystem, serving not only as a certification platform but also as a governance mechanism that connects MSMEs, halal facilitators, BPJPH, and other stakeholders. The quality of governance, data integrity, user readiness, and the digital controls implemented heavily influence the effectiveness of platforms like SIHALAL. (Wahyuni & Handoko, 2025). Therefore, assessing governance vulnerabilities in SIHALAL is crucial to accelerate certification while maintaining accountability, transparency, and halal assurance.

Agency Theory, developed by Jensen and Meckling (1976), states that information asymmetry occurs when one party in an employment relationship has more complete access to information than the other. (Salma Nurul Fadhilah et al., 2024). In the self-declaration halal certification scheme, the PPH facilitator acts as an "agent" who knows the real conditions of MSMEs in the field. At the same time, the BPJPH and the Fatwa Committee, as "principals," can only access digital documents in the system. Limited physical supervision by the principal creates a moral hazard; agents can take actions that benefit themselves financially without being directly detected by the monitoring system. (Salma Nurul Fadhilah et al., 2024). This can lead to data manipulation such as falsifying product photos, using documentation that does not match actual conditions, or presenting inaccurate raw material information. (Tasrip et al., 2017). These opportunistic actions are exacerbated if adequate independent verification mechanisms do not support the quantitative target-based compensation system. To complement Agency Theory's explanation of information asymmetry, this study also utilizes the Fraud Triangle. (Machado & Gartner, 2017). This framework explains why individuals commit fraud through three coexisting elements: pressure in the form of quantitative demands and financial incentives; opportunity, due to weak system controls and verification; and rationalization, as a justification for deviant behavior that is considered normal or not significantly detrimental. Applied studies (Mendes de Oliveira et al., 2022) Confirm that these three elements can operate simultaneously even in organizations with formal management systems, particularly when internal oversight mechanisms are not robust enough to close the opportunity gap for fraud. In the context of PPH (Indonesian Financial Reporting Agency) assistance, these three elements can coexist. Analysis of rationalization factors requires examining not only the drivers of fraud but also the mechanisms for its prevention. In Indonesia, legal sanctions for violations of halal validation can help curb fraudulent behavior and strengthen controls. These findings reinforce the argument that in the self-declared halal certification ecosystem, the absence of active independent auditors and strict sanctions contributes to the emergence of rationalization elements within the Fraud Triangle framework. (Deb, 2025; Salman, 2023). Pressure arises from the quota-based compensation system; opportunities stem from the lack of automated validation in SIHALAL; and rationalization may stem from the perception that the simplified assistance process poses no real risk to consumers. This integration of Agency Theory and the Fraud Triangle provides a more comprehensive analytical basis for explaining fraud risk patterns in self-declared schemes than using a single approach. However, (Freeman, 2025) cautions that the Fraud Triangle has inherent limitations in explaining complex and systemic fraud, where institutional environmental factors, group dynamics, and structural pressures are mutually reinforcing. Therefore, the integration of Agency Theory and Maqasid Syariah in this study addresses these limitations by adding the dimensions of normative motivation and principal-agent structure, providing analytical depth beyond the three triggering elements of the Fraud Triangle. (Freeman, 2025).

Epistemologically, all Sharia law aims to realize the welfare of servants (*mashlahat al-ibad*). Imam Al-Ghazali divided *Maqashid Sharia* into five pillars: safeguarding religion (*Hifdzuddin*), life (*Hifdzun Nafs*), reason (*Hifdzul Aql*), descendants (*Hifdzun Nasl*), and wealth (*Hifdzul Mal*) (Ghazali, 2021). In its development, the application of Maqashid Sharia has now expanded to the governance of Islamic institutions, the Islamic financial system, and value-based digital ecosystems (Ali & Suleiman, 2023). Although the concept of Maqasid Sharia is drawn from classical literature, this study also examines the development of contemporary literature that operationalizes these principles in digital governance, thereby making the theoretical framework more relevant to the current digital halal ecosystem (Irma

Suryani Lubis & Muslim Marpaung, 2026). In digital halal products, data manipulation during the certification process can *diminish* the credibility of the halal assurance mechanism and hinder the achievement of religious protection (*Hifdzuddin*) and consumer protection (*Hifdzun Nafs*) (Nurillah, 2023). Certification that is not supported by data integrity can undermine public trust in the national halal assurance ecosystem. Therefore, spiritual compliance in the digital ecosystem demands data accuracy and integrity equivalent to real-world law enforcement standards (Munawar & Mugiono, 2024). Integrating the *Maqashid Syariah perspective* into the governance framework makes this research technically relevant and has normative legitimacy in Islamic economic law. Protecting consumers as the weaker party in contractual relationships is also consistent with the objectives of *Hifdzun Nafs*, as emphasized in consumer protection studies highlighting how detrimental standard clauses and weak oversight often exacerbate the unequal position between service providers and consumers. Hence, strengthening regulations, law enforcement, and public awareness are prerequisites for achieving fair and balanced protection (Aminullah, 2026). Similar principles apply in the digital halal certification ecosystem, where data integrity and process transparency serve as substantive consumer protection measures.

The use of geotagging and digital timestamps in government public service applications has been empirically proven to prevent fraud by establishing the location and time that users cannot retroactively manipulate. (Ricardianto et al., 2023). A digital non-repudiation system that automatically records all input entities without manual intervention is a key requirement for accountable IT governance. (Brito et al., 2025). These two technologies are relevant for SIHALAL because they can verify that the mentoring process is actually carried out at the relevant MSME location, *thereby* preventing duplication of documentation across locations. Artificial intelligence (AI) is used as a technical reference to detect forgery in halal authentication systems. Research (Sunmola et al., 2025) shows that a Convolutional Neural Network (CNN) model trained on a cloud-based public service image dataset can achieve an accuracy of over 92% in detecting digital image manipulation in the test dataset used. Furthermore, a multimodal fusion approach that simultaneously integrates text and image analysis has been shown to improve the accuracy of detecting manipulated content compared to a single-modality approach. (Lin et al., 2024) demonstrated that a text-image fusion model is capable of achieving more robust performance in detecting counterfeit content. This approach could be adopted to develop a next-generation SIHALAL verification module that analyzes the correspondence between text descriptions of raw materials and image documentation uploaded by PPH. In this study, the three technologies were not developed as production systems, but rather formulated as functional requirements recommended for integration into the development of SIHALAL features by the BPJPH technical team.

**Table 1.** Conceptual Architecture of CNN Model for Image Verification on SIHALAL

Layer	Function
Input Layer (224×224)	Receive and process certification images as system input
Convolution Layer 1 + ReLU	Extracting basic features from images, such as shapes, edges, and visual patterns
Max Pooling Layer	Reducing data dimensions to improve processing efficiency
Convolution Layer 2 + ReLU	Extracting more complex and specific visual features
Max Pooling Layer	Reduce noise and retain important features.
Fully Connected Layer	Combining all the extracted features for the classification process
Softmax Output Layer	Generates a prediction of whether an image is suspected of fraud/manipulation or not.

Table 1 presents the conceptual architecture of the proposed Convolutional Neural Network (CNN) model for image verification on the SIHALAL platform. This model is designed to identify indications of duplication, manipulation, or discrepancies in visual documentation uploaded during the halal certification process. This architecture is still conceptual and intended as a system development recommendation for further research. Therefore, it has not been implemented or operationally tested in the SIHALAL environment.

**Table 2.** Conceptual Specification of Training Dataset for AI-Based Image Verification on SIHALAL

Dataset Categories	Planned Number of Images
Product Images	4,000
Production Facility Image	3,000
Raw Material Documentation	2,000
Location Verification Image	1,000
<b>Total</b>	<b>10,000</b>

Table 2 presents the conceptual specifications of the proposed dataset for developing the AI Image Verification module on the SIHALAL platform. This dataset is planned to include product images, production facility images, raw material documentation, and site verification images obtained during the halal certification process. All images will be labeled as original, duplicated, manipulated, or suspicious to support the supervised learning process. This dataset specification is still conceptual and is compiled as a system development recommendation for subsequent research. Therefore, the number of datasets, the labeling process, and the model validation mechanism still require further empirical testing before being implemented in the SIHALAL operational environment. Model performance should not be evaluated solely based on accuracy. Additional performance indicators, such as precision, recall, F1-score, and area under the ROC curve (AUC), are recommended to provide a more comprehensive assessment of fraud-detection capability and classification reliability.

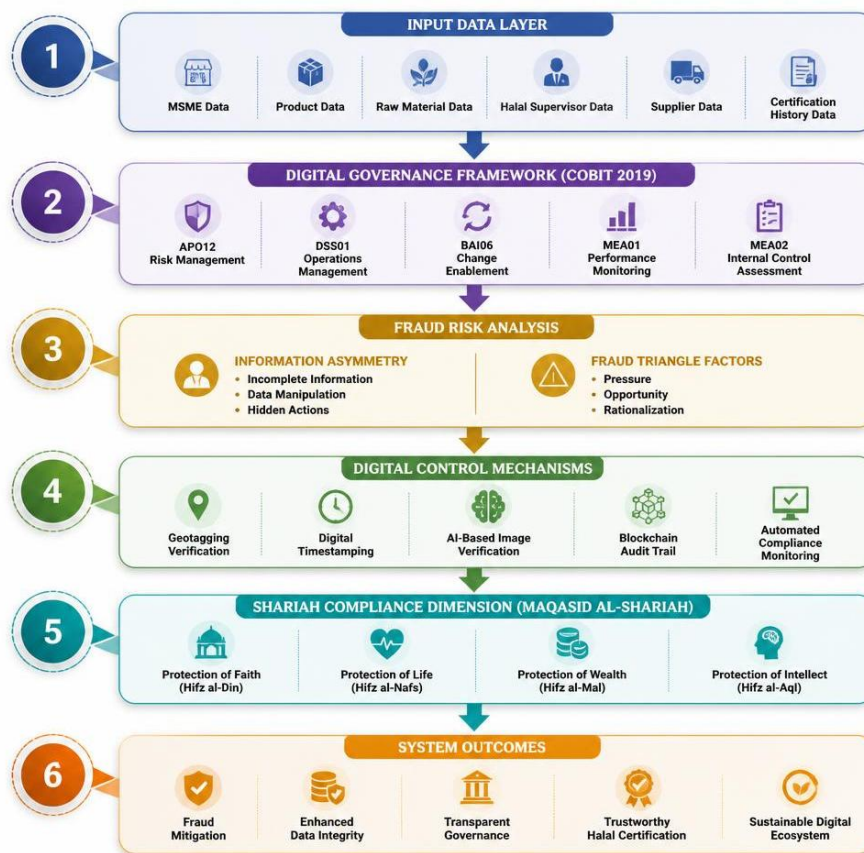
Location verification through geotagging is not completely immune to manipulation. Several studies have identified vulnerabilities in GPS spoofing techniques and fake location apps that can generate misleading geographic coordinates. Therefore, geotagging needs to be complemented with additional validation mechanisms, such as server-side verification, device authentication, and audit logging, to improve the reliability of location evidence. Digital timestamps help maintain time integrity by providing a verifiable record of when certification activities took place. However, their reliability can be affected by metadata changes, device clock manipulation, and inconsistencies in server synchronization. Therefore, a trusted timestamp mechanism and centralized server validation are needed to ensure the authenticity of the time records. In SIHALAL, the proposed AI-based image verification mechanism will use a dataset of images of products, production facilities, and MSME locations collected during the certification process. This category of images is expected to provide the visual information necessary to identify potential duplication, inconsistencies, or manipulation in certification records.

Conceptually, the proposed architecture follows a simple image verification workflow. Certification images are submitted as input and processed through a Convolutional Neural Network (CNN) model. The extracted visual features are then compared through a similarity detection process to identify duplicate or suspicious images. If the similarity level exceeds a predetermined threshold, the system can trigger a fraud alert for further manual review by the certification authority. However, the proposed AI image verification mechanism remains a conceptual recommendation rather than a fully implemented solution. Its effectiveness can be affected by false positives, false negatives, variations in image quality, and dataset dependence. Therefore, additional technical development, dataset generation, and model validation are required before operational implementation in SIHALAL. In addition to technical accuracy, dataset quality and representativeness are also crucial in developing an AI-based image verification system. An imbalanced dataset, or one overly dominated by certain product categories, geographic regions, or MSME characteristics, can introduce bias into the machine learning model. This can affect the fairness and reliability of the system, as the model may perform better on certain datasets. In halal certification, which is based on fairness and accountability, the development of diverse, representative, and validated datasets is essential for the fair and consistent application of AI verification mechanisms across various business actors. Therefore, evaluating data bias and testing model fairness needs to be part of the ongoing research agenda before AI is implemented in SIHALAL's operational environment. In this study, geotagging, digital timestamps, and AI-based image verification are positioned as proposed digital control mechanisms to support the future development of SIHALAL, rather than as technologies already implemented and empirically tested in the current certification system.

The Governance Layer uses COBIT 2019 as its primary framework, focusing on APO12 (risk management), DSS01 (operational controls), BAI06 (change management), MEA01 (performance monitoring), and MEA02 (internal control monitoring). Within this governance layer, the Risk Layer utilizes Agency Theory and the Fraud Triangle as analytical perspectives to explain how information asymmetry, pressure, opportunity, and rationalization can create moral hazard conditions. To address these vulnerabilities, the Digital Control Layer introduces geotagging, digital timestamps, AI-based image verification, and audit trails as control mechanisms for prevention and detection. These controls align with recent studies highlighting the importance of AI-based governance, digital verification, and fraud prevention mechanisms in public digital platforms. (Mushtaq & Onkal, 2026). Specifically, (Mushtaq & Onkal, 2026) identified that agentic-based AI systems can simulate and detect cyber-attack patterns and digital fraud on e-government platforms more proactively than static rule-based systems, making them relevant as a technical reference in designing the AI Image Verification module on SIHALAL.

The Sharia Compliance Layer ensures that all governance and control mechanisms remain compliant with the principles of Maqasid Sharia, specifically Hifdzuddin (protection of religion) and Hifdzun Nafs (protection of human welfare). With this integration, the framework is expected to achieve three main objectives: reducing fraud risks, improving data integrity, and providing reliable halal certification services. This framework serves as both a governance model and a

Sharia-compliant information system architecture, integrating governance, risk management, digital controls, and Islamic ethical principles into a unified certification ecosystem. This approach aligns with recent studies highlighting the strategic role of Maqasid Sharia in digital governance and the sustainability of the halal value chain. (Mohamad Puad & Asep Saepul Hamdi, 2025), (Irma Suryani Lubis & Muslim Marpaung, 2026), (Sari et al., 2026) Specifically proposed a conceptual framework integrating Islamic principles and digital technology for sustainable halal supply chain management, emphasizing that aligning sharia values with digital mechanisms not only strengthens product integrity but also systematically builds Muslim consumer trust. Furthermore, the efficiency of commodity supply chains also determines the fairness of value distribution for business actors; supply chain efficiency analysis studies show that the large number of intermediaries, weak market integration, and limited access to technology suppress the margins received by producers, so that institutional strengthening and information transparency are key to improving the welfare of micro-entrepreneurs (Ikhsan Nendi et al., 2026). In the context of SIHALAL, transparent digital control mechanisms can play an analogous role by reducing information asymmetry and strengthening the position of MSMEs in the halal certification ecosystem.



**Figure 1.** SIHALAL-Based Sharia-Compliant Information System Framework for Fraud Mitigation

The proposed Sharia-Compliant Information System Framework is structured as a multi-layered architecture to strengthen digital governance and mitigate fraud risks in the SIHALAL-based halal certification ecosystem. This framework begins with the SIHALAL Input Layer, which includes MSME data, product information, raw material documentation, and halal supervisor records submitted through the certification platform. These inputs serve as key information assets supporting the halal verification and certification process. This architecture is developed based on contemporary perspectives on digital governance and the implementation of halal technology, emphasizing the importance of integrating governance mechanisms with organizational and technological capabilities. (Magfiratun & Awaludin, 2024).

### 3. Methods

This study employs an Explanatory Sequential Mixed-Methods design based on Creswell's model. (Susilowati et al., 2018) with a sequence of data collection starting from the quantitative phase to map the main obstacles and vulnerabilities of digital governance in the SIHALAL system. The qualitative phase was then carried out to delve deeper into the sociological motives and theological perspectives of actors in the field. (Karyani et al., 2024). This approach was chosen because the issues studied encompass both quantitative dimensions, such as the level of understanding of MSMEs, certification barriers, and perceptions of fraud risk, as well as qualitative dimensions, such as *moral hazard patterns*, motivations of PPH facilitators, and the relevance of *Maqashid Syariah principles* in halal digital governance. The integration of these two types of data forms the basis for developing a Shariah-Compliant Digital Governance Framework, which was subsequently validated against the COBIT 2019 control standard and *Maqashid Syariah*. This study also considers organizational and environmental factors that can influence technology implementation, not only technical aspects. The evaluation of technology adoption in this study includes organizational readiness, management support, regulations, and external environmental conditions that influence the effectiveness of digital system implementation. The overall research flowchart is shown in Figure 2.

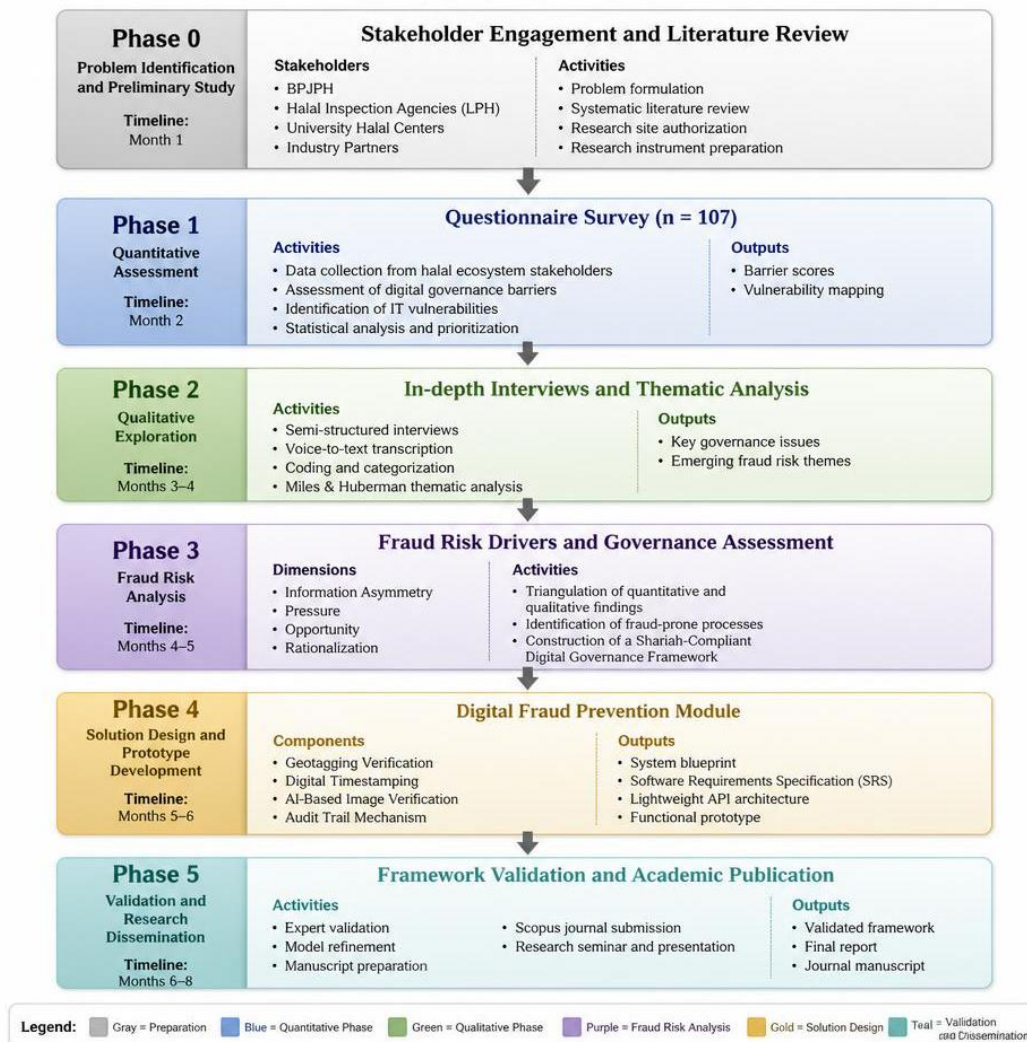


Figure 2. Research Flowchart

The study population consisted of MSMEs fostered by the Halal Center, partners of BPJPH, who had applied for or were undergoing the *self-declaration halal certification process* through the SIHALAL platform. The sample size was determined using the Slovin formula with a 10% error rate, requiring a minimum of 100 respondents (Nurlia & Mahpudin, 2023). The data collection process yielded 107 valid questionnaires, with 88.38% of respondents coming

from the culinary and food and beverage (F&B) sectors. The culinary and food-and-beverage sectors dominated this sample composition. Hence, the research findings likely reflect the characteristics and certification experiences of MSMEs in these sectors and may underrepresent non-food MSMEs in the halal certification ecosystem. In addition to the Slovin calculation, the number of 107 respondents was deemed sufficient for the exploratory correlational analysis that is the focus of this study. Since the primary objective was to identify patterns of relationships and associations among variables related to digital governance, digital literacy, and fraud risk perception, rather than to test a complex causal model, this sample size was sufficient to yield relevant statistical estimates of these relationships. Thus, the need for descriptive and correlational analyses in this study was met. In addition to using the Slovin calculation, a post-hoc statistical power analysis was also used to assess whether the sample size was sufficient for correlation analysis. According to Cohen (1988), a sample of 107 respondents provides statistical power greater than 0.80 to detect a moderate effect ( $\rho$  around 0.30–0.40) at  $\alpha = 0.05$ . (Sample Size for Pearson's Correlation, n.d.) Therefore, this sample size is considered sufficient to find a statistically meaningful association between the variables studied (Wiradhany et al., 2019).

The *purposive sampling* technique was used. (Wiguna et al., 2024) with the following inclusion criteria: (1) MSMEs assisted by Halal Center partners; (2) have applied for halal certification under the *self-declare scheme*; (3) are active on the SIHALAL platform; and (4) are willing to complete the questionnaire during the data collection period voluntarily. MSMEs that have never interacted with the SIHALAL system were not included in the sample. For qualitative research subjects, the *snowball sampling technique* was applied. (Izzah & Syabrina, 2025). The sample size of 107 has exceeded the minimum generally recommended for exploratory correlational analysis, especially for nonparametric association testing. Because the focus of this study is to identify relationship patterns, not to estimate population parameters or test complex causal models, this sample is considered sufficient to provide a meaningful statistical picture regarding governance variables and perceived fraud risk.

Initial informants were recruited from Halal Center administrators and BPJPH officials, who then recommended additional informants with direct, relevant experience in the *self-declaration halal certification process*. The number of informants was determined using the principle of data saturation, which is reached when the information obtained is repetitive and no new themes emerge. (Alam et al., 2022). Key informants included BPJPH regulatory authorities, senior auditors from the University of Indonesia's Halal Certification Body (LPH), internal Halal Center administrators, halal experts, and five active PPH facilitators experienced in the *self-declaration process*. Although purposive sampling enabled the selection of relevant respondents, generalization of findings requires caution because the sample was dominated by MSMEs assisted by the Halal Center, which may differ from the general MSME population. Prior to use, the questionnaire was tested for validity and reliability. The test results indicated that all instruments met the validity and reliability criteria, making them suitable for use in this study. The sample size of 107 MSMEs was deemed sufficient to achieve the research objectives and to represent the characteristics of the MSME population of self-declared halal-certified *practitioners* targeted by the study.

Primary data were collected through two instruments: (1) a validated *Google Forms -based questionnaire* administered to 107 MSMEs; and (2) structured in-depth interviews with key informants that were digitally audio-recorded and transcribed verbatim. Secondary data were derived from halal certification regulatory documents, publicly available operational and user guidelines for SIHALAL, and the 2024 BPJPH annual report. (Nugraha et al., 2024). Secondary data were used for triangulation and to strengthen the context of the analysis, rather than as the primary data source. The quantitative instrument consisted of 38 indicators covering five main dimensions: (1) halal digital literacy; (2) perceived ease of use of the SIHALAL platform; (3) quality of the PPH assistance process; (4) obstacles to implementing halal certification; and (5) perceived risk of *fraud* in the *self-declare scheme*. All indicators were measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) (Riofita & Iqbal, 2022). The interview instrument was designed as a semi-structured questionnaire covering topics such as digital governance, mentoring experiences, and perceptions of data integrity risks. Quantitative data were analyzed using descriptive statistics to obtain an overview of the frequency distribution, mean, and percentage for each instrument dimension. (Gierend et al., 2023).

The *Spearman correlation* test was used to examine the relationship between perceived weaknesses in SIHALAL digital controls (variable X) and the perceived level of *fraud risk* in the *self-declared halal certification process* (variable Y) (Djatsa, 2020). The Spearman test was chosen because it uses an ordinal measurement scale and does not require the assumption of normality in the data distribution. The Spearman correlation analysis in this study aims to measure the strength and direction of the relationship between variables, not to prove a causal relationship. Therefore, all quantitative findings are interpreted as statistical associations among the variables studied. Although a statistically significant relationship is found, this result cannot be used to conclude that one variable directly causes changes in

another variable. Testing causal relationships requires additional methodological approaches, such as longitudinal designs, experiments, or Structural Equation Modeling (SEM), which are outside the scope of this study. Therefore, the interpretation of the research results focuses on identifying patterns of inter-variable relationships to understand potential digital governance risks in the SIHALAL-based halal certification ecosystem. The Spearman correlation test is used to identify the strength and direction of statistical relationships between variables, but not to prove a causal relationship. All significant relationships found should be interpreted as associations between variables, not as evidence of direct causal influence. Establishing causal relationships requires different research designs, such as longitudinal studies, experiments, or more complex causal analysis models. Qualitative data were analyzed using Miles and Huberman's (1994) interactive analysis model, which consists of three stages (Muhamad, 2020) : (1) data reduction, (2) data presentation, and (3) inductive drawing of conclusions based on field data patterns and categories. Testing was conducted using statistical software prior to the main analysis to ensure the research instrument's quality (Khairi et al., 2025).

The validity of the instrument items was tested using *the Pearson Product-Moment correlation, and an item was declared valid if the calculated r value exceeded the table r value at the 5% significance level*. Instrument reliability was measured using *Cronbach's alpha, with a minimum threshold of 0.70 per Nunnally (1978)*. (Juhanda et al., 2025). Instruments that did not meet these two criteria were revised or deleted before the questionnaire was distributed to the entire sample. The credibility of the qualitative data was maintained through two procedures. First, source triangulation was conducted by comparing information from BPJPH informants, LPH auditors, PPH facilitators, and MSME actors to verify the consistency of the findings. (Goni et al., 2022). Second, *member checking* was conducted by returning the interview summary to key informants to confirm the accuracy of the interpretation before using it as the basis for analysis. (Prasetyo & Fatima, 2022). To assess the relevance and feasibility of the proposed framework, this study conducted an expert review with six experts: three halal and sharia economics experts, two senior LPH auditors, and one information systems expert. (Setik et al., 2023). The experts were asked to review *the framework's key components, namely the integration of COBIT 2019, Agency Theory, the Fraud Triangle, Maqashid Syariah, as well as recommendations for geotagging, digital timestamps, and AI image verification technologies*. By combining geographic coordinates (Geotagging) and verified timestamps (Digital Timestamps), the system can improve verification that photo uploads were made at the appropriate location and time. (Akib & Mujahid, 2025). This mechanism can minimize opportunities for the use of outdated photos or the exchange of image assets among MSMEs. However, its effectiveness depends on additional technical controls to prevent manipulation of location and metadata.

#### 4. Result and Discussion

Certification status data shows that 71.0% of respondents are still in the process, 17.8% are already certified, and 11.2% will apply for certification.

**Table 3.** Respondent Profile (n = 107)

Characteristics	Category	n (%)
Business Sector	Culinary/ F&B	94 (87.9%)
	Non-culinary	13 (12.1%)
Certification Status	Already certified	19 (17.8%)
	In the process	76 (71.0%)
	Planning to apply	12 (11.2%)
Major Obstacles	Delay in file verification	27 (25.2%)
	Lack of quality mentoring	26 (24.3%)
	Indirect cost burden	22 (20.6%)
Advanced Digital Literacy	Not following advanced digitalization	59 (55.1%)
	Following some	34 (31.8%)
	Actively following digitalization	14 (13.1%)

Source: Primary Data (2025), processed by researchers.

The average digital literacy score for MSMEs was the lowest ( $M = 2.83$ ;  $SD = 0.91$ ), indicating that respondents' digital capacity remained below the midpoint on the Likert scale. Conversely, dependence on PPH had the highest average ( $M = 3.86$ ;  $SD = 0.77$ ), indicating a fairly strong structural dependence on field agents. As many as 71.0% of MSMEs are still in the certification process, indicating that the adoption of digital halal certification continues to face various obstacles and is an important indicator of systemic barriers to its implementation. Low digital literacy scores indicate

that MSMEs' ability to use technology remains limited, thereby hampering the effective adoption of the digital halal system.

**Table 4.** Descriptive Statistics of Main Constructs (n = 107)

Construct/Variable	Min	Max	Mean	Elementary School
Digital Literacy for MSMEs	1	5	2.83	0.91
Understanding Halal Certification Procedures	1	5	3.42	0.87
BPJPH/SIHALAL Service Satisfaction	2	5	3.53	0.79
Fraud Risk Perception in SIHALAL	1	5	3.71	0.84
Intensity of PPH Assistance	1	5	3.28	0.95
Dependence on Companions	2	5	3.86	0.77
Certification Process Speed	1	5	2.97	1.02
Indirect Cost Burden	2	5	3.62	0.88

Source: Primary Data (2025), processed by researchers.

Validity testing was conducted using *Pearson correlation (r)* between item scores and the total construct score. Items were considered valid if  $r > 0.30$ . Reliability testing was conducted using *Cronbach's Alpha ( $\alpha$ ) coefficient* with a minimum limit of 0.70. The obtained Alpha values (0.797–0.852) indicated good internal consistency. Descriptive statistical results should be compared with broader data or studies to interpret the findings in context and to represent the general condition of MSMEs.

**Table 5.** Results of Instrument Validity and Reliability Tests

Construct	r Pearson ( range item)	Cronbach's $\alpha$	Information
Digital Literacy for MSMEs	0.734–0.812	0.831	Valid & Reliable
Understanding Certification Procedures	0.701–0.789	0.804	Valid & Reliable
BPJPH/SIHALAL Service Satisfaction	0.689–0.801	0.816	Valid & Reliable
Fraud Risk Perception	0.712–0.843	0.852	Valid & Reliable
Intensity of PPH Assistance	0.698–0.779	0.809	Valid & Reliable
Dependence on Companions	0.721–0.834	0.841	Valid & Reliable
Certification Process Speed	0.668–0.792	0.797	Valid & Reliable
Indirect Cost Burden	0.693–0.801	0.813	Valid & Reliable

Description: All item  $r$  values  $> 0.30$  (valid); all  $\alpha$  values  $> 0.70$  (reliable).

Of the 107 MSME respondents, the majority still face administrative uncertainty. Seventy-six respondents (71.0%) are still in the halal certification process, and 12 respondents (11.2%) are just planning to submit an application. The three main obstacles in the self-declaration ecosystem are delays in file verification (27 respondents; 25.2%), low-quality assistance (26 respondents; 24.3%), and the indirect burden of certification costs (22 respondents; 20.6%). The large number of files still in process indicates administrative and technical obstacles, such as limited verification capacity, incomplete documents, or technical issues with the SIHALAL platform. Furthermore, 55.1% of business actors have not kept up with further developments in digitalization, resulting in many MSMEs ultimately handing over account authority and data entry entirely to PPH Facilitators. The relationship between variables was tested inferentially using the Spearman correlation test ( $\rho$ ) because the data were measured on an ordinal (Likert) scale. Digital literacy was measured using five indicators: fraud risk perception, dependence on companions, and four other constructs, each rated on a 1–5 Likert scale.

**Table 6.** Results of Spearman Correlation Test between Systemic Variables (n=107)

Variable Pairs	Spearman's $\rho$	p-value	Interpretation
Rendahnya Literasi Digital ↔ Persepsi Risiko Fraud	0.624	$< 0.001^{**}$	Strong positive
Keterlambatan Verifikasi Berkas ↔ Ketergantungan pada Pendamping PPH	0.581	$< 0.001^{**}$	Strong positive
Kualitas Pendampingan ↔ Kelengkapan Pengisian Data SIHALAL	0.497	$< 0.001^{**}$	Moderate positive
Ketidakpahaman Prosedur Halal ↔ Status Berkas "Dalam Proses"	0.443	$< 0.001^{**}$	Moderate positive

Beban Biaya Tidak Langsung ↔ Persepsi Risiko Penundaan Sertifikasi	0.389	< 0.001**	Weak-moderate positive
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Note: \*\* significant at  $\alpha = 0.01$  (two-tailed). Correlation strength: 0.00–0.19 = very weak; 0.20–0.39 = weak; 0.40–0.59 = moderate; 0.60–0.79 = strong; 0.80–1.00 = very strong (Schober et al., 2018). The p-value is written as < 0.001 because, statistically, probability never reaches absolute zero.

Spearman's test results confirmed that low digital literacy had the strongest positive relationship with perceived fraud risk ( $\rho = 0.624$ ;  $p < 0.001$ ). This finding indicates that respondents with lower levels of digital literacy perceive a higher risk of fraud than those with higher levels, a pattern further confirmed by qualitative data. Spearman's correlation indicates the strength and direction of the relationship between variables, not a causal relationship; interpreting causality requires an experimental or longitudinal research design, which is beyond the scope of this study. The significant correlation between delays in file verification and reliance on PPH assistants ( $\rho = 0.581$ ;  $p < 0.001$ ) descriptively indicates that administrative obstacles in the certification process are closely related to increased structural dependence on field agents, a condition that, within the *Agency Theory framework*, indicates the potential for strengthening information asymmetry between agents and principals. The results of qualitative data analysis using Miles and Huberman's (1994) interactive model of in-depth interview transcripts with stakeholders indicate that the accumulation of administrative files is associated with the emergence of conditions that informants perceive as a potential systemic moral hazard. From an *Agency Theory perspective*, the relationship structure between BPJPH, as the principal, and PPH Facilitators, as agents, exhibits significant information asymmetry: fatwa authorities and regulators can access data only in static text and uploaded image files on the application dashboard, without the ability to perform real-time physical verification. This pattern aligns with the *Spearman coefficient*, which is quite strong between low digital literacy and perceived fraud risk ( $\rho = 0.624$ ), theoretically indicating a relationship between the digital literacy gap and increased perceptions of potential opportunistic actions by agents. This finding is consistent with (Umi Cholifah et al., 2026), who reported substantial barriers to the adoption of digital halal technology among MSMEs. Their study highlighted that limited multi-dimensional readiness and structural implementation challenges often hinder the effective utilization of digital halal assurance systems. In the context of this study, the relatively low levels of digital literacy observed among MSMEs may be related to a greater reliance on intermediaries and higher perceptions of governance vulnerabilities in the certification process. Conversely, public enthusiasm for developing digital business competencies remains high when relevant education and training pathways are available. This is evident in a study of 387 informants on interest in developing digital business programs, in which the majority of respondents considered strengthening digital literacy and skills a strategic necessity for economic growth and business competitiveness. (Guterres et al., 2025). These findings suggest that interventions to improve digital literacy could strengthen MSMEs' independence in the halal certification process and reduce structural dependence on field agents.

Compensation schemes based on quantitative targets (e.g., the number of certificates issued) can create incentives misaligned with quality-assurance objectives. Based on the perceptions and experiences expressed by informants, there are indications of suspected practices such as: (1) duplication of commodity images, namely the use of the same product photo documentation for several different MSMEs to expedite passing visual verification; and (2) inactive halal supervisors and the inclusion of formal third-party identities without actual involvement in overseeing the production process. Both of these indications stem from informants' perceptions during interviews and have not been confirmed through formal document audits; therefore, they should be treated as allegations requiring verification. Within the *Fraud Triangle framework* (Machado & Gartner, 2017), all three triggering elements, quantitative target pressure (pressure), weak automated system validation (opportunity), and the rationalization that process simplification does not result in real harm (rationalization), conceptually coexist in the *self-declaration*. These findings also support the broader literature on digital fraud prevention. Saranya & Chandrasekar (2026) emphasize the increasingly important role of artificial intelligence and machine learning techniques in strengthening fraud detection and risk governance mechanisms within digital ecosystems. While the current study does not empirically apply AI-based fraud detection, the proposed AI-based image verification mechanism conceptually aligns with this development. It can provide an additional layer of preventative control within the SIHALAL ecosystem.

The proposed framework is conceptualized as a multi-layered Shariah-Compliant Information Systems Architecture, designed to address the governance vulnerabilities identified in the SIHALAL ecosystem. The framework integrates six interconnected layers: (1) SIHALAL Input Layer, which manages data on MSMEs, products, raw materials, and halal supervisors; (2) Governance Layer, which applies COBIT 2019 principles to support risk management and operational controls; (3) Risk Layer, which interprets information asymmetry and moral hazard through the perspectives of Agency Theory and the Fraud Triangle; (4) Digital Control Layer, which incorporates geotagging, digital timestamps, AI-based image verification, and audit trails; (5) Shariah Compliance Layer, which aligns digital

governance mechanisms with the objectives of Maqasid Shariah; and (6) Output Layer, which aims to strengthen fraud mitigation, data integrity, and trustworthy halal certification services. Through this architecture, the framework places digital governance, risk management, information systems controls, and Islamic ethical principles within an integrated certification ecosystem. Thus, the proposed framework should be interpreted as a governance architecture and information system intended to support fraud risk mitigation, not as an empirically validated technological solution.

**Table 7.** Mapping of COBIT 2019 Domains to the Proposed System Functional Requirements

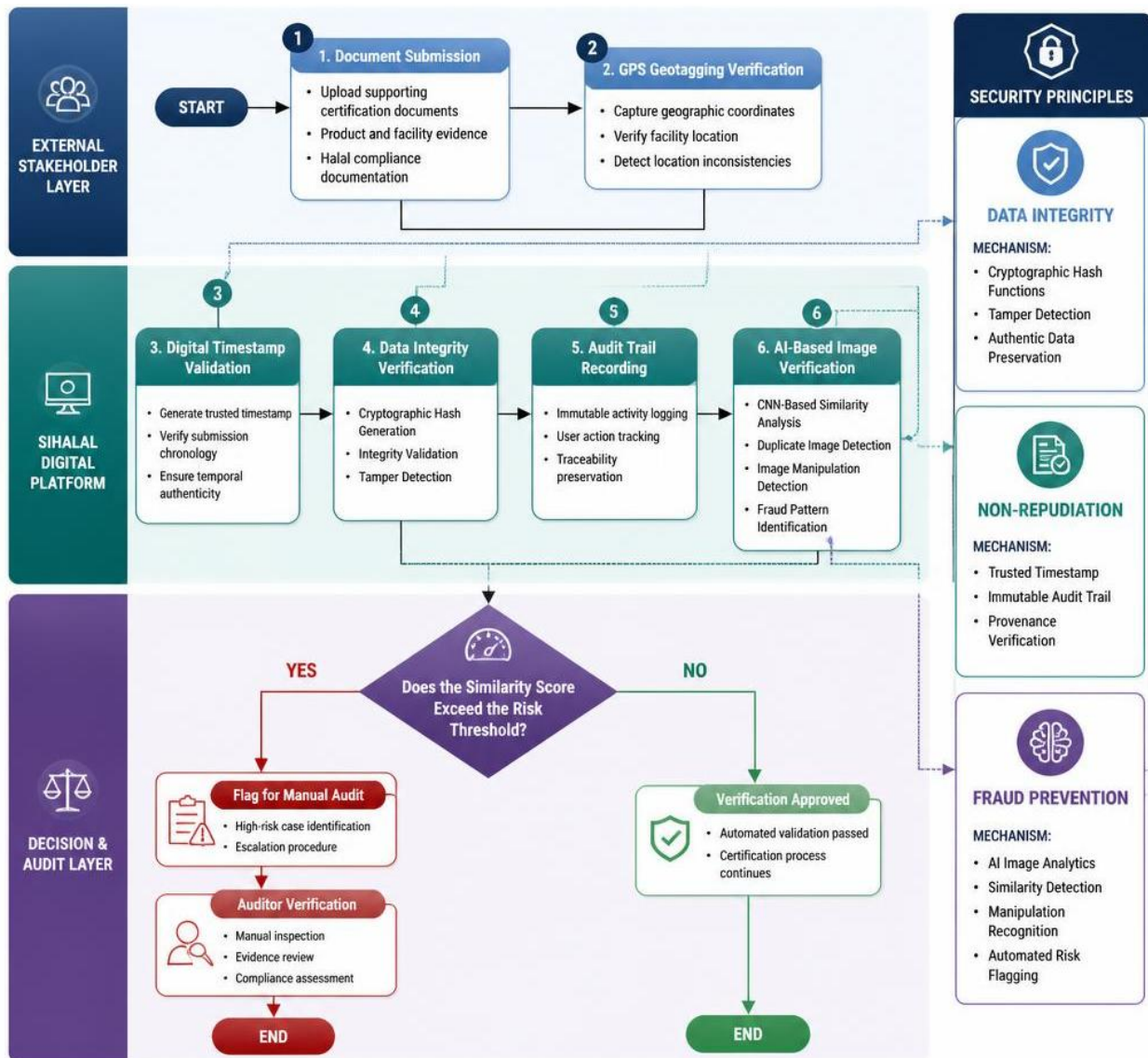
COBIT 2019 Domain	System Functional Requirements
DSS01 (Managed Operations)	Geotagging-based location validation to ensure the mentoring process is carried out at the appropriate location
APO12 (Managed Risk)	Fraud risk monitoring and risk level assessment based on metadata and documentation validation results
BAI06 (Managed IT Changes)	Implementation and management of the AI Image Verification module to detect image duplication or manipulation
MEA01 (Performance and Conformance Monitoring)	Monitoring and validation of digital timestamps to ensure the time integrity of documentation
MEA02 (System of Internal Control Monitoring)	Audit trail recording and review of user activity to support the principle of non-repudiation

Table 7 shows how the COBIT 2019 governance principles are translated into more operational functional requirements in the proposed framework. This approach aims to link governance aspects with technical implementation, so that each recommended digital control has a clear governance basis and can be implemented as a system feature to help mitigate fraud risks in the SIHALAL ecosystem.

This framework, developed from the experience of SIHALAL Indonesia, offers principles relevant to other digital certification systems facing challenges such as digital governance, information asymmetry, and fraud risks. The integration of digital controls, risk-based governance, and accountability can be applied across various certification ecosystems, both in the halal sector and in other sectors that utilize digital verification and documentation. This research is not only beneficial for SIHALAL but also provides lessons for developing more transparent, accountable, and reliable digital certification systems. This framework is based on the characteristics of digital halal certification governance in Indonesia through the SIHALAL platform, and its basic principles can be adapted to digital halal certification ecosystems in other countries. Challenges such as information asymmetry between verifiers and regulators, limitations in digital validation, and the risk of document manipulation are not unique to Indonesia. Still, they are also present in many halal certification systems undergoing digital transformation. Therefore, the integration of risk-based governance, digital controls, and the Maqashid Syariah principles proposed in this study can serve as a reference for regulators, halal certification bodies, and digital platform managers in various countries who wish to improve integrity and accountability in the certification process.

From an information systems perspective, a lightweight, API-based functional module is recommended to lock and verify EXIF metadata in images during field visits by facilitators. (M. Maheswari et al., 2025). By combining geographic coordinates (Geotagging) and verified timestamps (Digital Timestamps), the system can ensure that photos are uploaded directly to the MSME location at the correct time, thereby preventing the misuse of old photos or the exchange of images between MSMEs.

This pseudocode demonstrates how geotagging, digital timestamps, and image verification work together to support the principle of non-repudiation in the certification of digital assets. With this approach, the system not only verifies the authenticity of the location and time of documentation but also adds controls to prevent data duplication or manipulation that could compromise the integrity of the certification. The *framework* also suggests using a Convolutional Neural Network (CNN)-based image similarity detection model at the Halal Center level as an initial screening step before data is sent to the BPJPH central server. (Naudiyal et al., 2026). However, this recommendation to use a CNN remains conceptual and requires further testing, including the creation of a training dataset and model evaluation in the next development phase. From a management perspective, the framework applies the values of Maqasid Syariah to the IT quality control system by mapping recommended digital controls, minimizing risks, and upholding the Maqasid Syariah pillars. While AI and geotagging can enhance the effectiveness of digital verification, integration with blockchain can also strengthen data transparency, traceability, and reliability, helping to reduce the risk of human error and fraud. These findings need to be compared with other research and data to understand better their significance and impact on the challenges in adopting digital halal technology.



**Figure 3.** Interaction Flow of Geotagging, Digital Timestamp, and AI Image Verification to Support Non-Repudiation on SIHALAL

Table 8 shows that each proposed digital control mechanism not only helps mitigate specific fraud risks but also results in a system that supports integrity and accountability in the halal certification process. The recommended digital controls can be directly mapped to the relevant COBIT 2019 control domains and have normative legitimacy through the pillars of Maqasid Sharia. The integration of IT governance, risk management, digital controls, and Sharia principles makes the proposed framework not only technically structured but also normatively accountable within the context of Islamic economic law. Thus, this framework serves as a Shariah-Compliant Information Systems Framework that connects digital control mechanisms to maintain halal integrity and the public interest.

The expert review results indicate that the proposed framework is considered relevant and conceptually feasible for strengthening the digital governance of self-declared halal certification. The experts assessed that geotagging and digital timestamps can improve the integrity of the field verification process by strengthening the validity of the location and time of documentation. Meanwhile, AI image verification is considered a promising approach for detecting duplication and manipulation of digital documentation, although it still needs technical testing before it can be implemented in practice. Although AI-based image verification is included in the framework as a potential fraud-prevention mechanism, its effectiveness has not been empirically demonstrated in this study. No image datasets were collected, CNN architectures were trained, or model performance was evaluated. Therefore, the discussion of AI image

verification covers only conceptual system design and governance recommendations. Empirical validation of AI-based controls remains an important agenda for future research. Although AI Image Verification is a component of the proposed framework, it should be emphasized that it remains a conceptual recommendation and has not been empirically validated in this study. This study did not build a dedicated image dataset, train a Convolutional Neural Network (CNN) model, test model performance, or conduct an operational implementation in the SIHALAL environment. Therefore, the discussion of AI Image Verification in this study is limited to system architecture design and digital governance recommendations for future development. Empirical validation of the effectiveness of AI-based verification mechanisms still requires further research, including dataset creation, model training, accuracy evaluation, and testing in real-world operational environments.

**Table 8.** Mapping of Digital Controls, Mitigated Risks, COBIT 2019 Domains, Maqashid Syariah, and System Outputs

Digital Control	Mitigated Risks	COBIT 2019 Domain	Maqashid Sharia	System Output (System Output)
Geotagging	Falsification of field visit locations; duplication of documentation between locations	DSS01, APO12	Hifdzuddin	Verified location integrity
Digital Timestamp	Manipulation of document upload times; reuse of old documentation	DSS01, MEA01	Hifdzuddin	Verified time integrity
AI Image Verification	Product image duplication; product photo falsification	APO12, BAI06	Hifdzuddin	Validate image authenticity
Digital Verification of Raw Materials	Inaccurate or unsafe raw material information	APO12, DSS05	Hifdzun Nafs	Traceability of raw materials
Audit Trail Non-Repudiation	Deletion or modification of the certification track record	MEA01, MEA02	Hifdzuddin & Hifdzun Nafs	Accountability and traceability of transactions

Source: Processed by researchers based on COBIT 2019 and Al-Ghazali (2021).

## 5. Conclusion

First, the vulnerability of the SIHALAL digital platform's governance in data validation and control mechanisms remains limited, as does the low digital literacy among MSMEs. 55.1% do not keep up with developments in digitalization. The Spearman correlation test showed a significant positive relationship between low digital literacy and perceived risk of system vulnerability ( $\rho = 0.624$ ;  $p < 0.001$ ), indicating only an association, not causality. *Second*, qualitative findings indicate that information asymmetry between the PPH Facilitator and BPJPH leads to administrative manipulation. Analysis of Agency Theory, Fraud Triangle, and Maqashid Syariah shows that both hinder the protection of the integrity of the halal system (*Hifdzuddin*) and consumers (*Hifdzun Nafs*). This study combines COBIT 2019 and these three theories into a layered information system architecture, starting from input, governance, risk, digital control, and Sharia compliance to output. Recommended control mechanisms include geotagging, digital timestamps, AI image verification, and audit trails. Experts validated that the framework is relevant and conceptually feasible. Third, the focus is on integrating IT governance, fraud risk theory, and *Maqashid* Syariah into an information systems framework, rather than developing new verification technologies. The study has limitations, such as its cross-sectional design, correlation results that do not demonstrate causality, a sample consisting of only one Halal Center network dominated by the F&B sector, indications of data manipulation that have not been forensically verified, and the AI Image Verification (CNN) module that is still conceptual and has not been empirically tested.

For further research, it is recommended to increase the sample size, conduct longitudinal studies, develop a CNN model, and collaborate with BPJPH to test the framework's operational feasibility. Furthermore, expanding the scope of the study to non-food sectors is also important, given that the challenges of implementing a halal supply chain in the cosmetics and pharmaceutical industries differ from those in the food and beverage (F&B) sector. (Pertiwi et al., 2026). Integrating these multi-sector perspectives will strengthen the generalizability of the Shariah-Compliant Information Systems Framework proposed in this study.

## Acknowledgements

The authors would like to thank the Halal Product Assurance Agency (BPJPH) of the Ministry of Religious Affairs of the Republic of Indonesia for providing access to regulatory documents and policy references related to the SIHALAL platform. We also thank the Halal Center for assisting in collecting data from MSMEs participating in self-declared halal certification. We want to express our appreciation to all key informants, including BPJPH officials, senior auditors from the Halal Inspection Institute (LPH) of the University of Indonesia, halal experts, and active Halal Product Process Facilitators (PPH), for sharing their time and experiences, which enriched the results of this research. This research did not receive any grants or specific funding from any institution, whether public, commercial, or non-profit.

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