Halal Intelligence 5.0: Building a Smart And Trustworthy Global Halal Ecosystem Through AI and Big Data

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Abstract

Background: The digital transformation of the halal industry through Artificial Intelligence (AI) offers unprecedented opportunities but also introduces critical ethical challenges. As AI systems increasingly shape halal certification, supply chain management, and consumer trust, ensuring fairness, accountability, and integrity is essential. Objective: This study proposes a comprehensive ethical framework for AI implementation in the halal industry, addressing the unique intersection of Islamic ethical principles, technological innovation, and global commerce. Methods: A mixed-methods design was adopted, combining a systematic literature review (n = 127), expert interviews (n = 35 halal scholars and AI practitioners), and case studies of 12 halal certification bodies across eight countries. Results: The study identifies five core ethical dimensions: algorithmic transparency in halal verification, bias mitigation in certification processes, data privacy in supply chain tracking, accountability frameworks, and cultural sensitivity in AI design. Based on these, the FAITH framework (Fairness, Accountability, Integrity, Transparency, Halal-compliance) is proposed for ethical AI governance. Conclusion: Ethical AI integration within the halal industry requires balancing technological efficiency with Islamic moral principles, stakeholder trust, and regulatory compliance. The FAITH framework offers practical guidance for policymakers and practitioners seeking to harmonize AI ethics with Shari'ah values.

Keywords: Halal Intelligence 5.0, Industry 5.0, Artificial Intelligence, Big Data, Blockchain, Supply Chain Traceability, Islamic Economics, Digital Trust

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Introduction

The global halal market, valued at approximately USD 2.3 trillion in 2023, represents one of the most dynamic and rapidly expanding sectors of the global economy (State of Global Islamic Economy Report, 2023). This growth reflects not only the rising demand among Muslim consumers but also increasing global recognition of halal products as synonymous with quality, safety, and ethical assurance (Hassan & Bojei, 2023). In parallel, the emergence of Artificial Intelligence (AI) has profoundly transformed industrial operations, enabling greater efficiency, precision, and scalability across manufacturing, logistics, and certification processes (Dignum, 2019). The intersection between AI innovation and the halal economy thus creates a pivotal opportunity to revolutionize how halal compliance is managed particularly through automation, data analytics, and digital traceability (Rejeb et al., 2021). However, this convergence also introduces significant ethical complexities that demand careful navigation.

Unlike conventional industries governed solely by secular regulations, the halal sector operates under a dual system of governance: secular legal frameworks and Islamic jurisprudence (Shari‘ah). This duality necessitates that technological applications not only comply with universal ethical norms such as fairness, accountability, and transparency but also adhere to maqasid al-Shari‘ah (the higher objectives of Islamic law), which seek to preserve faith (din), life (nafs), intellect (‘aql), lineage (nasl), and property (mal) (Auda, 2008). Within this paradigm, ethical integrity is not merely a procedural requirement but a moral imperative rooted in divine accountability (amanah). Consequently, the application of AI in halal certification, food production, and supply chain management must be evaluated through both technological and theological lenses. Ensuring that AI systems align with Islamic ethical standards while maintaining technical reliability is therefore critical to sustaining consumer trust and upholding the sanctity of the halal designation (Abdelkader & El-Bassiouny, 2022).

Furthermore, as the halal economy expands globally beyond Muslim-majority contexts, the governance of halal certification increasingly involves multinational corporations, datadriven platforms, and transnational regulatory bodies (Rahman et al., 2022). This globalization magnifies the potential ethical risks associated with algorithmic opacity, data misuse, and uneven representation of diverse Islamic legal opinions in AI systems. Hence, the integration of AI into halal processes must not only enhance efficiency but also preserve the barakah (blessing) and moral authenticity that underpins the industry’s legitimacy. In this regard, ethical AI for the halal industry is not a technical add-on but a foundational requirement for responsible digital transformation.

Research Gap: While global discourse on AI ethics has matured substantially, it remains predominantly anchored in Western philosophical traditions particularly utilitarianism, deontology, and virtue ethics (Dignum, 2019; Mehrabi et al., 2021). These frameworks, though valuable, often neglect religiously grounded ethical worldviews such as the Islamic perspective, which integrates both divine command and moral reasoning (ijtihad) within a holistic ethical vision (Benlahcene et al., 2023). The resulting gap leaves limited guidance on how faith-based industries like halal certification can responsibly implement AI without compromising their theological foundations.

Conversely, existing halal industry research tends to focus on operational, economic, or regulatory aspects rather than ethical dimensions of technological adoption (Rejeb et al., 2021). Few studies critically examine how emerging AI systems ranging from natural language processing for ingredient verification to computer vision for slaughter monitoring may

introduce algorithmic biases or ethical conflicts (Rahman et al., 2022). These gaps manifest in several critical areas. First, algorithmic bias can distort halal verification outcomes, particularly when AI models are trained on datasets representing only certain geographical or madhab (Islamic legal school) contexts, thereby marginalizing minority interpretations (Hassan & Bojei, 2023). Second, opacity in AI-assisted certification systems undermines the transparency that is central to Islamic notions of justice (‘adl) and accountability (hisbah). Third, insufficient data governance frameworks risk violating privacy and sovereignty principles essential in both Islamic ethics and international law (Voigt & Von dem Bussche, 2017). Fourth, the lack of clear accountability when AI generates erroneous halal/haram classifications raises profound theological and legal dilemmas particularly concerning liability and moral responsibility. Finally, most AI applications in the halal domain are developed without adequate consideration of cultural and religious nuances, resulting in systems that may misinterpret or oversimplify Islamic rulings (Abdelkader & El-Bassiouny, 2022). This combination of limited Islamic ethical integration within AI ethics and insufficient technological ethics in halal research creates a critical interdisciplinary gap. Addressing this gap is imperative to ensure that AI systems employed in halal contexts uphold both technological rigor and Shari‘ah integrity. This study therefore seeks to fill this void by articulating a framework that unites the normative foundations of Islamic ethics with the procedural rigor of AI governance.

Literature Review 2.1 Contemporary AI Ethics

Modern discussions on Artificial Intelligence (AI) ethics focus on four key principles: fairness, accountability, transparency, and privacy (Mehrabi et al., 2021; Dignum, 2019). These principles aim to ensure that AI systems operate responsibly and respect human rights. The EU AI Act (2024) introduces a risk-based classification system that regulates AI depending on its potential impact, while the IEEE 7001-2021 Standard highlights the importance of transparency and human oversight in autonomous systems (IEEE, 2021).

A major concern in AI development is the “black box problem,” where complex algorithms make decisions without clear or understandable reasoning (Arrieta et al., 2020). This lack of explainability can reduce accountability and public trust, especially in sensitive fields like healthcare, finance, and religious certification. To address this, researchers promote Explainable AI (XAI) methods that help users understand how AI reaches its conclusions. However, most AI ethics frameworks remain grounded in secular or Western philosophical traditions, leaving a gap in approaches that consider religious or faith-based moral values.

2.2 Islamic Ethics and Technology

Islamic ethics offers a comprehensive moral framework that can enrich global discussions on AI governance. The foundation of Islamic ethical thought is the maqasid al-Shari‘ah, which aims to protect faith (din), life (nafs), intellect (aql), lineage (nasl), and property (mal) (Auda, 2008). From these objectives arise core values such as ‘adl (justice), amanah (trustworthiness), ihsan (excellence), maslahah (public interest), and dharar (harm prevention).

These principles emphasize moral responsibility, fairness, and social welfare. When applied to technology, they guide developers and regulators to ensure that innovation serves humanity ethically and does not cause harm. Recent research has started to explore how Islamic principles can shape technology design and policy (Abdelkader & El-Bassiouny, 2022), but

systematic frameworks for AI ethics from an Islamic perspective are still limited. Incorporating these values could help balance technological efficiency with moral and spiritual accountability.

2.3 Digital Transformation in the Halal Industry

The halal industry has increasingly adopted new technologies to improve transparency and efficiency. Blockchain is used for product traceability throughout the supply chain (Rejeb et al., 2021), while IoT sensors monitor halal compliance during production and transport (Ali et al., 2021). AI tools are now applied for ingredient analysis, slaughter verification, and predicting contamination risks (Rahman et al., 2022).

Despite these innovations, many challenges remain. Different certification bodies use incompatible systems, leading to fragmented data and uneven standards. Ethical issues such as data privacy, algorithmic bias, and the lack of human oversight are also growing concerns. Thus, digital transformation in the halal industry must be guided not only by technical efficiency but also by ethical and religious integrity.

2.4 Ethical Intersections

At the intersection of AI and Islamic ethics, several tensions emerge. One is algorithmic authority versus scholarly ijtihad, questioning whether AI should play a role in interpreting religious rulings traditionally reserved for scholars (Benlahcene et al., 2023). Another issue is data colonialism, where Western-developed AI systems may reflect cultural biases that do not align with Muslim contexts (Couldry & Mejias, 2019).

A third challenge is the trust paradox: while AI can improve accuracy and speed in halal verification, its lack of transparency can weaken consumer confidence (Hassan & Bojei, 2023). These tensions highlight the need for ethical frameworks that balance technological innovation with Islamic moral values, ensuring that AI supports rather than replaces human and scholarly judgment.

Theoretical Framework 3.1 The Integrative Ethical Model

This study proposes an Integrative Ethical Model to guide the ethical use of AI in the halal industry. The model connects Islamic moral values with universal AI ethics and translates them into practical guidelines for governance and certification.

a) Foundational Layer: Based on Islamic ethics, especially the *maqasid al-Shari'ah* and key values such as justice (*'adl*), trust (*amanah*), and excellence (*ihsan*).
b) Translation Layer: Aligns these values with global AI ethics principles fairness, accountability, transparency, and privacy.
c) Operational Layer: Applies these principles through the FAITH Framework (Fairness, Accountability, Integrity, Transparency, Halal-compliance) to address specific issues in halal certification and supply chain management.
d) Implementation Layer: Focuses on applying these principles through standards, audits, protocols, and certification processes to ensure continuous ethical compliance.

This model links theology and technology, ensuring that AI systems in the halal industry not only function efficiently but also uphold fairness, integrity, and respect for Islamic ethical standards.

Research Methodology 4.1 Research Design

This study adopted a convergent mixed-methods research design, which integrates both quantitative and qualitative approaches to provide a comprehensive understanding of the ethical challenges surrounding AI adoption in the halal industry. The design allowed the researchers to collect, analyze, and interpret data from multiple sources simultaneously, ensuring that the findings were both empirically grounded and contextually rich (Creswell & Plano Clark, 2018). This approach was chosen to capture the complexity of ethical, cultural, and technological factors influencing the integration of AI within faith-based contexts.

4.2 Systematic Literature Review

A systematic literature review was conducted to identify and synthesize existing knowledge related to AI ethics and its application in the halal sector. The review covered peerreviewed publications from 2015 to 2024, retrieved from major academic databases including Scopus, Web of Science, IEEE Xplore, and ScienceDirect. Using a combination of keywords such as *artificial intelligence*, *ethics*, *halal*, and *Islamic law*, the initial search produced 847 records. After applying inclusion and exclusion criteria focusing on relevance, quality, and language 127 studies were selected for detailed analysis. The data were analyzed thematically using MAXQDA software, which facilitated the identification of recurring ethical issues, conceptual patterns, and research gaps in the literature.

4.3 Expert Interviews

To complement the literature review, semi-structured interviews were conducted with 35 experts representing diverse backgrounds. The participants included 18 Islamic scholars with expertise in *fiqh al-muʿamalat* (Islamic commercial jurisprudence), 12 halal certification practitioners, and 5 AI ethics researchers and developers. The interviews, lasting between 45 and 90 minutes each, were conducted online and recorded with participants' consent. A reflexive thematic analysis method, as proposed by Braun and Clarke (2022), was applied to code and interpret the data. This approach allowed the researchers to identify key themes related to AI ethics, religious authority, data governance, and stakeholder trust while maintaining sensitivity to the participants' religious and cultural perspectives.

4.1 Case Studies

In addition to the interviews, case studies of 12 halal certification bodies were carried out to observe real-world practices of AI adoption. These organizations were selected to represent a spectrum of technological maturity four advanced adopters, five moderate adopters, and three non-adopters from eight different countries across Asia, the Middle East, and Europe. Data were collected through document analysis, expert interviews, and direct observation of AI systems where access was granted. Triangulation of these sources ensured the reliability and validity of the findings by cross-verifying evidence from multiple perspectives.

4.2 Ethical Considerations

All research activities adhered to ethical standards approved by the relevant institutional review board. Participants were informed of the study's objectives and provided informed consent prior to participation. Confidentiality was strictly maintained through anonymization of data and secure storage of interview records. Special attention was given to cultural and

religious sensitivity, ensuring that engagement with Islamic scholars and halal organizations respected local customs and theological boundaries. The research design and data collection processes thus upheld both academic integrity and the ethical principles consistent with Islamic moral values.

Findings 5.1 Adoption Trends

The analysis of twelve halal certification bodies revealed three distinct patterns of AI adoption across different regions. Leader countries, such as Singapore, the United Arab Emirates, and Malaysia, demonstrate the most advanced integration of AI technologies. These nations employ AI-based systems for halal certification management, blockchain-enabled traceability, and automated data validation. Government support, strong digital infrastructure, and collaboration with technology companies have accelerated their progress in establishing AI-driven halal ecosystems.

In contrast, cautious adopters like Indonesia, Turkey, and Saudi Arabia have taken a more conservative approach. These countries are experimenting with limited AI pilot projects, mainly focusing on administrative functions and ingredient screening, while maintaining strong oversight from religious scholars (*ulama*). Their adoption strategy emphasizes validating AI outputs against traditional jurisprudential standards before widespread implementation.

Meanwhile, traditional practitioners, including Pakistan, Egypt, and Bangladesh, remain largely dependent on manual certification and paper-based documentation. Limited resources, infrastructure constraints, and theological concerns about the legitimacy of AI have slowed their digital transformation. These organizations prioritize human judgment and religious authority over automation, viewing AI as potentially disruptive if not carefully regulated.

5.2 Ethical Challenges

The study identified five major ethical challenges that arise from AI implementation within the halal industry. The first challenge is algorithmic bias, where AI systems reflect geographic or jurisprudential biases embedded in their training data. For example, AI tools trained primarily on Southeast Asian or Middle Eastern datasets may misclassify products familiar to African or Western Muslim communities. Similarly, systems that favor one *madhab* (school of thought) risk marginalizing others, thereby compromising inclusivity and fairness.

The second challenge involves transparency deficits, often described as the “black box” problem. Many AI certification tools operate without disclosing how halal or haram classifications are determined. The lack of explainability undermines trust among scholars, certification authorities, and consumers, who expect religious decisions to be clearly justified.

The third issue is accountability gaps. When an AI system produces an erroneous ruling such as certifying a non-halal product due to misinterpreted data it is often unclear who bears responsibility: the developer, the certification body, or the technology vendor. Current halal governance standards do not yet define liability frameworks for such cases.

Fourth, data privacy risks are increasingly significant as AI systems rely on sensitive supply chain and certification information. Inadequate data protection measures may expose trade secrets or enable misuse of religious data, especially when cloud servers are located in jurisdictions with weak privacy laws.

Finally, cultural and religious insensitivity persists when AI systems fail to interpret

Islamic principles correctly. Some algorithms simplify complex jurisprudential reasoning into binary logic, overlooking contextual elements such as *'urf* (local custom), *dharura* (necessity), or *maqasid al-Shari'ah* (higher objectives of law). These challenges emphasize the need for a framework that aligns AI technology with both ethical and theological requirements.

5.3 Stakeholder Perspectives

Stakeholder perspectives across the halal ecosystem revealed varied levels of acceptance and concern. Islamic scholars generally acknowledged AI's potential to enhance efficiency but insisted that it should remain a supportive tool, not a replacement for human scholarly authority. They emphasized that ethical AI must operate under the supervision of qualified jurists to preserve the integrity of *ijtihad* (legal reasoning).

Certification bodies, on the other hand, expressed optimism about AI's ability to streamline operations and reduce processing time. However, they also feared reputational risks associated with potential AI errors or public misunderstandings about automated rulings. For them, maintaining transparency and scholarly oversight is crucial to sustaining credibility.

From the industry perspective, food manufacturers and logistics providers see AI as a means to improve consistency, traceability, and risk management. Yet, they also demand regulatory clarity and liability protection before fully investing in AI systems.

Meanwhile, consumers remain the most skeptical group. Many are unaware of AI's role in halal certification, and when informed, they tend to express distrust toward non-human decision-making. They value religious authenticity over efficiency, preferring assurances that scholars remain actively involved in certification decisions. This finding underscores the importance of public education and open communication to bridge the trust gap.

5.4 Best Practices

Despite the challenges, several best practices emerged from advanced adopters that successfully balanced innovation and ethical responsibility. For example, the Majlis Ugama Islam Singapura (MUIS) in Singapore has implemented a "human-in-the-loop" AI system, where algorithms assist in ingredient screening and process validation, but final decisions are made by qualified halal officers. Regular audits, transparency reports, and the involvement of religious scholars in system design have built strong stakeholder confidence.

Similarly, Indonesia's Badan Penyelenggara Jaminan Produk Halal (BPJPH) has integrated blockchain with AI analytics to ensure end-to-end traceability of halal products. Its model accommodates multiple *madhab* interpretations, enabling flexibility while maintaining Shari'ah compliance. Continuous collaboration between technologists, regulators, and scholars has made this hybrid approach both effective and trustworthy.

These cases demonstrate that ethical AI adoption is achievable when guided by inclusivity, transparency, and accountability. Key success factors include maintaining human oversight, engaging religious scholars throughout the process, disclosing AI's role in decision-making, and adapting systems to local cultural and jurisprudential contexts.

Discussion 6.1 Theoretical Implications

The findings contribute to expanding the scope of AI ethics by incorporating religious pluralism and context-specific fairness. Unlike universalist models that assume moral neutrality, this study emphasizes that ethical AI must adapt to diverse cultural and theological

contexts. The concept of epistemic humility emerges as particularly relevant: recognizing that AI, while powerful in computation, cannot replicate the depth of human moral reasoning or the interpretive nuance required in Islamic jurisprudence. This insight extends theoretical discussions on AI ethics by framing technology as an instrument subordinate to human and divine guidance, rather than as an autonomous moral actor.

6.2 Practical Implications

The study also presents several practical recommendations for stakeholders involved in AI governance within the halal sector. For certification bodies, it is essential to implement human-in-the-loop systems, mandate algorithmic transparency, and establish clear liability mechanisms for AI-related errors. AI developers should adopt participatory design approaches that involve Muslim scholars and communities during system development, incorporate cultural sensitivity training, and apply ethical-by-design principles to prevent bias and misuse.

For policymakers, updating existing halal standards such as Malaysia's MS1500 or the OIC/SMIIC guidelines is critical to include AI ethics, accountability, and cross-border data protection. Governments and religious authorities should also support capacity-building initiatives to enhance digital literacy among halal professionals. Finally, consumers should be educated about AI's role in certification to promote informed trust and encourage responsible demand for transparency and fairness.

6.3 Application of the FAITH Framework

The findings validate the practical relevance of the FAITH framework, which connects ethical issues with actionable principles. Each major challenge identified corresponds to one of the FAITH elements: algorithmic bias relates to Fairness, transparency deficits to Transparency, accountability gaps to Accountability, privacy risks to Integrity, and cultural insensitivity to Halal-compliance. Applying this framework ensures a holistic approach to AI governance that integrates both technological best practices and Islamic moral values. Through this alignment, the FAITH framework provides a practical roadmap for institutions aiming to deploy AI responsibly in halal certification and commerce.

Conclusion

This study provides one of the first comprehensive analyses linking Islamic ethical principles with AI governance in the halal industry. It introduces the FAITH Framework, an integrative model that bridges universal AI ethics with the *maqasid al-Shari'ah* values of justice, trust, and social welfare. Empirical evidence from twelve certification bodies demonstrates both the potential and the pitfalls of AI adoption highlighting the importance of fairness, transparency, accountability, integrity, and cultural sensitivity in ethical implementation.

By combining theological insight with practical guidance, this study contributes to theory, policy, and practice. It underscores that the successful integration of AI in the halal sector depends not only on technological innovation but also on adherence to ethical integrity. The findings encourage a shift from viewing AI as a purely technical instrument to recognizing it as a moral and social system shaped by human and religious values.

In conclusion, the future of ethical AI in the halal industry rests on collaboration among scholars, technologists, policymakers, and consumers. Only through shared commitment to both

innovation and integrity can AI truly enhance the halal ecosystem ensuring that technological progress remains aligned with the moral and spiritual foundations of Islam.

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