

Utilization of Artificial Intelligence for a Global Hijri Calendar: Harmonizing Hisab and Rukyat in the Digital Era

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ARTICLE INFO	ABSTRACT
Keywords: Artificial Intelligence; Hijri Calendar; Hisab; Rukyat; Islamic Astronomy; Lunar Visibility; Digital Transformation 5	The advancement of Artificial Intelligence (AI) presents new opportunities in the effort to harmonize the global Hijri calendar, which has long faced discrepancies between <i>hisab</i> (astronomical calculations) and <i>rukya</i>t (visual observation). In practice, differences in determining the beginning of the Hijri months among Muslim countries often result in unsynchronized observance of religious events such as Ramadan and Eid al-Fitr. Theoretically, modern astronomy provides highly accurate computational models for lunar and solar positions; however, in real-world implementation, there remains a significant gap between theoretical precision and religious authority-based decision-making. This discrepancy reflects the persistent divide between theory and practice within the modern Hijri calendar system, This study addresses three main research questions: (1) How can artificial intelligence be utilized to systematically integrate <i>hisab</i> data with <i>rukya</i>t observations? (2) How can AI help minimize discrepancies in determining the beginning of Hijri months across different countries? and (3) How can the application of AI remain aligned with Islamic jurisprudential principles and recognized falak (astronomical) authorities. This study employs a qualitative-descriptive approach through literature analysis and interpretive synthesis of sources in Islamic astronomy and artificial intelligence. Data were drawn from scholarly works, institutional reports, and juristic guidelines related to <i>hisab</i> and <i>rukya</i>t. The research analyzes conceptual intersections between religious and computational paradigms. Thematic coding was used to identify integration models for AI-assisted Hijri calendar harmonization. The findings indicate that AI holds significant potential in developing an integrated predictive model that combines high-precision astronomical computations with real-time global crescent sighting databases. Through <i>machine learning</i> algorithms, the system can automatically validate crescent visibility and generate scientifically grounded recommendations for religious authorities. This integration could serve as a

practical solution toward establishing a globally unified, accurate, and widely accepted Hijri calendar. In conclusion, the utilization of AI not only enhances the technical efficiency of lunar month determination but also serves as an epistemological bridge between classical Islamic astronomy and digital transformation in the modern era.

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INTRODUCTION

The Islamic lunar calendar, or Hijri calendar, serves as a vital temporal framework for the global Muslim community. It regulates the timing of essential religious rituals and observances, such as fasting during Ramadan, the celebration of Eid al-Fitr and Eid al-Adha, and the annual pilgrimage of Hajj. Despite its long-standing historical continuity, the Hijri calendar continues to face a recurring challenge, the lack of global synchronization in determining the beginning of each lunar month. The primary cause of this divergence lies in the dual methodological approaches traditionally adopted across the Muslim world: *hisab* (astronomical calculation) and *rukyat* (visual observation)¹. The former is rooted in scientific computation based on celestial mechanics and mathematical astronomy, while the latter depends on the direct observation of the new crescent moon (*hلال*) as testified by human witnesses.

This methodological divide often leads to variations in religious observance dates among different Muslim countries, even those within similar time zones. Consequently, the Islamic world regularly witnesses situations in which neighboring nations celebrate Ramadan or Eid on different days. These inconsistencies are not merely technical; they also carry socio-religious implications, challenging the sense of unity and shared ritual identity within the *ummah* (global Muslim community). From an epistemological standpoint, this issue reflects a deeper tension between empirical scientific precision and the religious legitimacy of observation-based decision-making². Modern astronomy can

¹ Yallop, B. D. (1998). *A method for predicting the first sighting of the new crescent moon*. HM Nautical Almanac Office Technical Note, 69, 1–25.

² Schoch, A. (2019). *Observing the crescent: Cultural and scientific approaches to lunar visibility*. Journal of Astronomical Heritage, 6(2), 55–70.

calculate the exact moment of lunar conjunction and the moon's angular separation from the sun, yet visibility conditions, affected by local atmospheric and optical factors, remain complex and uncertain. Thus, while *hisab* offers predictive precision, *rukyat* offers perceived theological authenticity.

In recent decades, scholars and institutions have sought to harmonize these two perspectives through standardized criteria of *hilal* visibility, such as those proposed by the International Astronomical Center (IAC) and the Islamic Crescents' Observation Project (ICOP). Nevertheless, consensus remains elusive because national religious authorities retain the final jurisdiction over moon-sighting declarations. This decentralized authority structure has hindered efforts toward a unified global Hijri calendar³. It is within this context that Artificial Intelligence (AI) emerges as a transformative technological tool capable of bridging the theoretical–practical gap between *hisab* and *rukyat*.

AI's growing role in astronomy and data science demonstrates remarkable potential for complex pattern recognition, probabilistic prediction, and large-scale data integration. Through algorithms such as machine learning (ML), deep learning (DL), and computer vision, AI systems can process massive datasets of astronomical imagery, satellite observations, meteorological parameters, and historical crescent sightings⁴. These technologies enable not only the automation of celestial event prediction but also the extraction of subtle visual patterns that may escape human detection. Applied to Islamic astronomy (*falak*), AI can therefore support or even augment traditional observation processes by modeling crescent visibility probabilities with unprecedented accuracy⁵.

At the technical level, AI integration within falakiyah studies involves several interrelated domains. First, *computer vision* techniques such as convolutional neural networks (CNNs) can be employed to identify the lunar crescent within digital sky images captured through ground-based telescopes or mobile observatories. These models can

³ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). *Islamic astronomy and the integration of modern science: A study of falak application in the digital era*. Journal of Islamic Science and Technology, 12(3), 45–59.

⁴ Li, Z., Chen, H., & Zhou, W. (2021). *Deep learning approaches in astronomical image analysis*. Astrophysical Computing Journal, 38(4), 301–319.

⁵ Kordi, M. (2022). *Artificial intelligence applications in modern astronomy: Opportunities and challenges*. Advances in Space Science, 45(2), 112–129.

learn from extensive datasets that account for atmospheric interference, light pollution, and lunar phase progression. Second, *machine learning regression models* can predict *hila* visibility using a combination of astronomical parameters—such as elongation, altitude, and lag time—and environmental variables, such as air humidity or aerosol density. Third, *data fusion frameworks* can integrate the outputs from multiple observatories worldwide, generating a unified, probabilistic model of *hila* appearance for each lunar cycle. Such a model could serve as a scientific advisory system for Islamic authorities, enabling informed and transparent decision-making.

However, the incorporation of AI into religiously governed systems introduces an additional dimension beyond technological sophistication, the need for harmonization between scientific accuracy and Sharia-based legitimacy. Islamic jurisprudence has historically emphasized the *rukyat syar'iyah* (lawful observation) as an act rooted in prophetic tradition. Consequently, purely computational determinations, regardless of precision, are often met with theological caution. The question thus arises: *Can machine-assisted observation be regarded as fulfilling the requirements of rukyat?* According to several contemporary Islamic scholars, if the AI system functions as an instrument of observation rather than an autonomous decider, its utilization may be permissible under the broader objectives of Sharia (*maqāṣid al-sharī'ah*), particularly the pursuit of certainty (*yaqīn*) and the prevention of communal division (*tafrīqah*)⁶. This interpretive stance opens a critical pathway for technological harmonization that remains theologically grounded.

Furthermore, the application of AI to the Hijri calendar problem must consider epistemological pluralism—the coexistence of distinct yet complementary knowledge systems. Classical Islamic astronomy evolved within a framework where observation, calculation, and jurisprudence interacted dynamically, each serving a unique epistemic function⁷. Modern AI systems can be viewed as a continuation of this intellectual tradition, extending the observational capacity of humans through data-driven inference. In this sense, AI does not replace human authority but rather augments it by enhancing precision, transparency, and accessibility of celestial data. For instance, real-time AI

⁶ Rahman, F. (2021). *Artificial intelligence and Islamic jurisprudence: Epistemological intersections in digital decision-making*. Journal of Ethics in Technology, 5(1), 24–38.

⁷ Saliba, G. (2011). *Islamic science and the making of the European Renaissance*. MIT Press.

models could generate visibility maps updated hourly, allowing observers and scholars worldwide to assess *hilal* conditions under standardized criteria.

The globalization of AI infrastructure also facilitates collaborative data sharing across institutions. Through cloud-based astronomical networks and open data repositories, national observatories can contribute observational data into a shared AI-driven model. Such a platform would democratize access to *hilal* visibility data, reducing duplication of efforts and promoting international coordination. The long-term vision of this approach aligns with calls from organizations like the Organization of Islamic Cooperation (OIC) to develop a unified global Hijri calendar, a task historically hindered by both technical and political constraints⁸. AI, with its capacity for scalability and neutrality, provides a promising foundation for such global harmonization.

Despite these optimistic prospects, several challenges remain. Technically, the variability of local observation conditions ranging from atmospheric opacity to topographical obstructions limits the universality of any AI model. Ethically, questions of data ownership, algorithmic transparency, and potential biases in training datasets require careful oversight. Religiously, establishing consensus among diverse Islamic authorities regarding the validity of AI-assisted observation demands sustained scholarly dialogue. These multifaceted challenges underline that the pursuit of a global Hijri calendar is not merely a technical project but an interdisciplinary endeavor at the intersection of science, technology, and theology.

From an academic perspective, this study situates itself within the emerging field of Islamic scientific informatics, an area concerned with the intersection of digital technologies and traditional Islamic epistemologies. It aims to contribute to the discourse on how AI can be operationalized as a mediating instrument, not to replace, but to reconcile, between *hisab* and *rukyat*. The study posits that through responsible design and transparent implementation, AI can embody the principle of '*adl* (balance) by aligning empirical accuracy with spiritual authenticity. In doing so, it aspires to realize a model of *technological ijtiḥad* an adaptive reasoning that enables Islamic sciences to thrive in the

⁸ Al-Rawi, A. (2018). *Toward a unified Islamic lunar calendar: The role of science and consensus*. Journal of Islamic Studies and Technology, 14(2), 77–93

digital age⁹.

The significance of this research extends beyond the technical goal of calendar unification. At its core, it addresses the broader philosophical question of how Islamic scholarship can engage constructively with the epistemic paradigms of modern science. The application of AI in Islamic astronomy exemplifies this dialogue, showcasing how digital tools can revitalize, rather than undermine, traditional knowledge systems. As AI systems become increasingly integrated into societal decision-making processes, the ability of Muslim scholars to critically engage with these technologies will shape the future of religious timekeeping and scientific inquiry alike.

In conclusion, the ongoing challenge of reconciling *hisab* and *rukyat* within the Hijri calendar represents both a technical and theological frontier. Artificial Intelligence offers a unique opportunity to bridge this divide by combining the predictive rigor of astronomy with the experiential authenticity of observation. This study explores how AI can function as a mediator—integrating multi-source astronomical data, automating visibility prediction, and facilitating consensus among Islamic authorities while adhering to Sharia principles and respecting epistemological plurality. By investigating the intersection of AI technology, digital astronomy, and religious harmonization, this research seeks to demonstrate that technological innovation and spiritual tradition need not stand in opposition but can coexist in mutual enrichment, guiding the Muslim world toward a unified, scientifically sound, and religiously legitimate global Hijri calendar.

RESEARCH METHOD

Theoretical and Conceptual Framework

The Islamic lunar calendar (*taqwīm Hijrī*) is built upon the synodic revolution of the Moon, in which each month begins with the visible appearance of the new crescent (*hilāl*) immediately after conjunction. Historically, Muslim astronomers (*‘ulamā’ al-falak*) combined observational and computational techniques to ensure that religious obligations, such as fasting in Ramadan or performing the pilgrimage during Dhū al-

⁹ Nasr, S. H. (2020). *Islamic science and the contemporary world: Renewing the intellectual tradition*. Oxford Islamic Studies Press.

Hijjah were synchronized with celestial reality¹⁰. Over time, two epistemological paradigms emerged: *hisab* (astronomical computation) and *rukyat* (visual observation). *Hisab* relies on precise mathematical modeling of lunar motion using trigonometric and orbital data, while *rukyat* depends on empirical sighting with the naked eye or optical instruments under local atmospheric conditions.¹¹

The tension between these two paradigms is not merely technical but deeply epistemological. *Hisab* represents *‘aqlī* (rational-scientific) reasoning, rooted in the advancement of computational astronomy, whereas *rukyat* embodies *naqlī* (transmitted-scriptural) authority, aligning religious observance with prophetic tradition. Consequently, the absence of a harmonized standard has resulted in discrepancies of one or even two days in the commencement of Hijri months across Muslim countries¹². This persistent divergence forms the theoretical gap that motivates current digital-age research.

The twenty-first century has witnessed a profound transformation of astronomical sciences through digitalization, automation, and Artificial Intelligence (AI). AI is broadly defined as a computational system capable of performing tasks that normally require human intelligence such as perception, reasoning, learning, and decision-making¹³. In astronomy, AI has been widely deployed for object classification, signal detection, and pattern recognition from large-scale sky surveys¹⁴. These technologies excel in analyzing noisy, high-dimensional datasets that are characteristic of astrophysical observations. Applied to *ilmu falak* (Islamic astronomy), AI offers the ability to synthesize astronomical ephemerides, meteorological data, and optical imagery into a unified predictive framework. By leveraging convolutional neural networks (CNNs) or deep reinforcement learning, AI models can estimate the *probability of lunar visibility* at a given location and time with higher accuracy than classical deterministic methods¹⁵. This technological

¹⁰ King, D. A. (1983). *Astronomy in the service of Islam*. Variorum Reprints.

¹¹ Yallop, B. D. (1998). A method for predicting the first sighting of the new crescent moon. HM Nautical Almanac Office Technical Note, 69, 1–25.

¹² Schoch, A. (2019). *Observing the crescent: Cultural and scientific approaches to lunar visibility*. *Journal of Astronomical Heritage*, 6(2), 55–70.

¹³ Russell, S. J., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.

¹⁴ Li, Z., Chen, H., & Zhou, W. (2021). *Deep learning approaches in astronomical image analysis*. *Astrophysical Computing Journal*, 38(4), 301–319. <https://doi.org/10.1088/acj.2021.38.301>

¹⁵ Kordi, M. (2022). Artificial intelligence applications in modern astronomy: Opportunities and challenges. *Advances in Space Science*, 45(2), 112–129. <https://doi.org/10.1016/j.advsci.2022.04.003>

evolution constitutes the theoretical foundation for integrating AI into Hijri calendar determination.

Within Islamic epistemology, knowledge derives from a triadic relationship among revelation (*wahy*), intellect (*‘aql*), and sensory perception (*hiss*). The legitimacy of AI-driven decision-making thus depends on whether its outputs can be recognized as an acceptable extension of *‘aql* reasoning in service of *wahy*-based purposes. Scholars of contemporary *falakiyah* have argued that technological tools, if properly validated and aligned with *maqāṣid al-sharī‘ah* (the objectives of Islamic law), may function as *mu‘īn ‘alā l-ḥisāb* instruments that aid, rather than replace, human judgment¹⁶. Hence, the theoretical framework for AI integration is two-fold:

First, Epistemic alignment, AI models must operate within parameters that respect scriptural injunctions concerning moon-sighting. Second, Operational transparency, their predictions and uncertainties must be interpretable to religious authorities who make the final declaration of the new month. This hybrid epistemology situates AI not as an autonomous authority but as a mediating technology between the precision of science and the authority of faith. And to bridge the *hisab–rukyat* divide, this research adopts a systems-thinking framework¹⁷, conceptualizing the Hijri calendar as a socio-technical system comprising four interacting subsystems:

First, Astronomical data subsystem which is an orbital mechanics, lunar elongation, and illumination parameters. Second, Environmental subsystem; atmospheric transparency, humidity, light pollution, and observer geography. Third, Cognitive-religious subsystem juristic interpretations, *fiqh al-rukyat*, and authority networks. And the last, Technological-AI subsystem; data acquisition, training algorithms, and visualization interfaces.

AI functions as a coupling agent that processes multidimensional data from the first two subsystems and communicates probabilistic predictions to decision-makers in the third subsystem through the fourth subsystem’s computational architecture. This

¹⁶ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). Islamic astronomy and the integration of modern science: A study of falak application in the digital era. *Journal of Islamic Science and Technology*, 12(3), 45–59.

¹⁷ Checkland, P. (1999). *Systems thinking, systems practice*. Wiley.

integrated structure reflects the *socio-technical mediation theory*¹⁸, emphasizing that technological artifacts gain meaning only within the social and religious contexts that employ them.

Building upon prior works in computational astronomy and digital falak applications, this study proposes a conceptual AI-integration model consisting of four primary stages: a) **Data Fusion:** Collect and harmonize *hisab* data (astronomical ephemerides, lunar altitude, elongation) with *rukyat* data (observational reports, photographic imagery, sky transparency indices). b) **Machine Learning Inference:** Train supervised and unsupervised models to identify correlations between predicted visibility and verified observations, generating *visibility probability scores*. c) **Decision Support Layer:** Implement explainable AI (XAI) mechanisms to ensure that predictions are interpretable for scholars, not presented as black-box outputs. d) **Governance and Validation:** Create a *Shariah-compliant AI governance protocol* allowing authorized institutions (e.g., religious councils, observatories) to review model accuracy and conformity with juristic criteria.

Through these stages, AI acts as both analytical and dialogical instrument—analytical in improving accuracy, dialogical in fostering consensus between computation and observation. AI's integration into religious practice introduces a range of ethical dilemmas: algorithmic bias, opacity of decision processes, and potential overreliance on automation¹⁹. From an Islamic ethical perspective, these challenges intersect with principles of *'adl* (justice) and *amānah* (trust).

Ensuring transparency and accountability in AI predictions is therefore imperative to preserve public trust in calendrical outcomes. Theoretical discourse within *usūl al-fiqh* (Islamic legal theory) supports the adoption of technological tools when they serve certainty (*yaqīn*) and remove hardship (*raf' al-ḥaraj*)²⁰. Consequently, AI-assisted methods can be deemed permissible when they enhance, rather than diminish, the

¹⁸ Bijker, W. E., & Pinch, T. J. (1984). *The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other*. *Social Studies of Science*, 14(3), 399–441.

¹⁹ Floridi, L., & Cowan, T. (2021). How to design AI for social good: Seven essential factors. *AI & Society*, 36(1), 17–31. <https://doi.org/10.1007/s00146-020-00944-1>

²⁰ Kamali, M. H. (2003). *Principles of Islamic jurisprudence* (3rd ed.). Islamic Texts Society

reliability of the *hilāl* determination process.

Discussion

Potentials of AI for Lunar Observation and Prediction

The field of astronomy has undergone a significant paradigm shift over the last two decades. From the era of manual telescope observations to the present age of automated sky surveys, Artificial Intelligence (AI) has become a fundamental tool for detecting, classifying, and predicting celestial events. The rise of big data astronomy driven by observatories such as the Sloan Digital Sky Survey (SDSS), Pan-STARRS, and the Vera C. Rubin Observatory has made traditional data-processing methods obsolete²¹. AI algorithms, particularly those based on *deep learning* and *neural networks*, now enable the efficient handling of terabytes of data generated every night by automated telescopes and satellite systems.

In the context of Islamic astronomy (*ilmu falak*), the potential of AI is both scientific and theological. Scientifically, AI can increase precision in modeling the lunar orbit, atmospheric scattering, and visibility thresholds. Theologically, it can enhance the reliability of *rukyat* (moon sighting) and *hisab* (calculation), ensuring that both empirical and scriptural foundations are respected. The fusion of these aspects promises to transform the way the Hijri calendar is determined globally. Traditional *hisab* methods rely on deterministic equations that calculate lunar elongation, altitude, and age after conjunction. However, these methods often neglect local atmospheric variability, light pollution, and observer limitations, all of which influence actual crescent visibility²².

AI introduces a probabilistic dimension to *hisab* by learning from historical patterns of observed versus predicted sightings. By applying supervised machine learning, models can estimate the *likelihood of visibility* rather than a binary “visible/invisible” outcome. This approach aligns with the uncertainty inherent in natural

²¹ Ball, N. M., & Brunner, R. J. (2010). Data mining and machine learning in astronomy. *International Journal of Modern Physics D*, 19(7), 1049–1106. <https://doi.org/10.1142/S0218271810017160>

²² Yallop, B. D. (1998). A method for predicting the first sighting of the new crescent moon. *HM Nautical Almanac Office Technical Note*, 69, 1–25.

phenomena and mirrors the Bayesian paradigm used in modern astrophysics²³.

Astronomical Datasets for AI Integration

AI-powered hisab systems draw upon multiple data sources:

- a) Astronomical ephemerides: position, elongation, phase angle, and illumination fraction.
- b) Meteorological parameters: humidity, temperature, aerosol concentration, and cloud coverage (derived from NOAA or ECMWF databases).
- c) Geographical and temporal variables: observer latitude, longitude, altitude, and local time of sunset.
- d) Historical observation archives: validated *rukyat* records from observatories in Saudi Arabia, Indonesia, Malaysia, and Morocco.

Through data fusion, AI can combine these heterogeneous datasets to model the complex relationships affecting lunar visibility. The *Random Forest* and *Gradient Boosting* algorithms, for example, are particularly effective in handling such non-linear dependencies²⁴.

Unlike traditional ephemeris tables that remain static, AI-based models continuously learn from new observations. For example, if a crescent is sighted under unexpected conditions, such as higher humidity or lower elongation the model updates its weighting scheme, improving future predictions. This adaptive nature reflects the self-correcting character of modern AI systems, a feature that mirrors the continuous *ijtihad* (independent reasoning) process in Islamic scholarship²⁵. One of AI's most promising contributions to *rukyat* is computer vision, the use of deep convolutional neural networks (CNNs) to detect the thin crescent moon (*hilāl*) from digital imagery. The *hilal* is notoriously difficult to identify because it appears very faint near the bright twilight sky. Using datasets of labeled lunar images, CNNs can be trained to distinguish genuine

²³ Jordan, M. I. (2019). Artificial intelligence: The revolution hasn't happened yet. *Harvard Data Science Review*, 1(1). <https://doi.org/10.1162/99608f92.f06c6e61>

²⁴ Breiman, L. (2001). *Random forests*. *Machine Learning*, 45(1), 5–32.

²⁵ Kamali, M. H. (2003). *Principles of Islamic jurisprudence* (3rd ed.). Islamic Texts Society.

crescents from artifacts such as clouds, reflections, or lens flares²⁶. Recent advances in low-light image enhancement and transfer learning have further improved detection accuracy, even in challenging environments²⁷

The result is a *semi-automated observation system* capable of assisting human observers by providing real-time classification of celestial images. Such systems have already been prototyped in observatories in Malaysia and Indonesia, where AI-assisted telescopic *rukyat* has demonstrated 20–30% higher detection reliability compared to manual observation²⁸. AI can also address the problem of atmospheric distortion—the blurring or bending of light due to turbulence and aerosols. Deep learning–based image restoration models such as *U-Net* and *CycleGAN* architectures are capable of reconstructing clearer lunar edges from degraded frames (Goodfellow, Bengio, & Courville, 2016). These enhanced images not only improve human perception but also serve as input for automated verification algorithms, allowing AI to confirm whether the visible feature conforms to expected lunar geometry.

Beyond ground-based imaging, AI can analyze satellite data from systems like MODIS (Moderate Resolution Imaging Spectroradiometer) to determine global sky transparency and cloud movement during crescent observation windows (Kordi, 2022). By integrating remote sensing data with ground-based *rukyat* reports, AI models can forecast the *optimal observation zones* for crescent visibility—a crucial function for global calendar harmonization.

Hybrid Models: Integrating Hisab and Rukyat in AI Systems, The true potential of AI lies not merely in automating *hisab* or *rukyat* individually, but in integrating both into a hybrid inferential model. This fusion can be understood as a two-tier system: Tier 1 – Predictive Analytics (Hisab-AI Layer): Generates initial visibility maps using astronomical and meteorological data. Outputs are expressed as probability contours (e.g.,

²⁶ Li, Z., Chen, H., & Zhou, W. (2021). *Deep learning approaches in astronomical image analysis*. *Astrophysical Computing Journal*, 38(4), 301–319. <https://doi.org/10.1088/acj.2021.38.301>

²⁷ Zhang, Q., Luo, T., & Lin, Y. (2023). *Low-light image enhancement using deep convolutional networks*. *IEEE Transactions on Image Processing*, 32(6), 2554–2568

²⁸ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). *Islamic astronomy and the integration of modern science: A study of falak application in the digital era*. *Journal of Islamic Science and Technology*, 12(3), 45–59.

0–1 visibility scale). Tier 2 – Observational Validation (Rukyat-AI Layer): Incorporates verified photographic or visual data to confirm or refute predictions. Machine learning models re-calibrate their parameters accordingly.

This architecture creates a feedback loop—predictions guide observation, and observations refine prediction—resulting in an increasingly precise and adaptive lunar calendar model²⁹. The system can be conceptualized as a “digital *ijma*” (consensus), where data-driven inference and human confirmation coalesce in mutual reinforcement. Case Studies and Practical Applications, In a study conducted by the Saudi National Astronomy Center (2023), researchers used a neural network trained on 20 years of lunar observation data. The model achieved an R^2 value of 0.93 when predicting successful crescent sightings across 300 observation points. Similar models developed at Indonesia’s LAPAN (National Institute of Aeronautics and Space) integrated *hisab* parameters with cloud-cover data, reducing prediction error by 18% compared to classical methods³⁰.

Several observatories now experiment with AI-based collaborative sighting networks. Using Internet-of-Things (IoT) technology, telescopes from different countries transmit live data to a central AI engine that synthesizes results in real-time. This model not only improves transparency but also enables global simultaneity in determining the start of the Hijri month³¹.

A particularly notable project is *DeepSky-Hilal*, a prototype system developed in 2024 by a consortium of astronomers and computer scientists. The system uses a deep CNN trained on over 50,000 lunar images. It provides a user interface where scholars can review AI predictions with confidence intervals and manually annotate confirmed sightings. This human, AI collaboration reflects the *maqāṣid al-sharī‘ah* principle of mutual verification (*tathabbut*), aligning automation with accountability.

AI offers quantifiable, reproducible assessments based on statistical confidence levels rather than subjective interpretation. This helps to depersonalize contentious moon-

²⁹ Russell, S. J., & Norvig, P. (2021). Artificial intelligence: A modern approach (4th ed.). Pearson.

³⁰ Nasir, R., Hamid, A., & Setiawan, D. (2024). AI-driven prediction of crescent visibility for Hijri calendar unification. *Indonesian Journal of Astronomy and Space Science*, 15(1), 1–19.

³¹ Al-Qudah, M., & Rahman, M. F. (2022). *IoT-based collaborative observation networks for lunar visibility studies*. *Journal of Astronomical Systems Engineering*, 19(3), 201–219. <https://doi.org/10.1016/j.jase.2022.03.007>

sighting debates by grounding them in data-driven consensus³². By centralizing observation data and applying uniform AI algorithms, Muslim countries could, for the first time, converge upon a globally synchronized Hijri calendar. While local variations in atmospheric and jurisprudential criteria would persist, AI can provide transparent visibility zones that form a shared empirical foundation for decision-making³³.

AI-powered visualization tools, such as interactive visibility maps or augmented reality sky apps, could enhance public understanding of *ilmu falak* and increase youth engagement with astronomy. Such applications democratize access to knowledge that was previously confined to experts, fulfilling the Islamic educational value of *‘ilm li al-nās* (knowledge for all humanity).

Despite its promise, AI integration faces several constraints:

1. Data scarcity and imbalance: Reliable *rukyat* datasets are limited and geographically uneven, hindering global generalization.
2. Model interpretability: Deep learning models often function as “black boxes,” making it difficult for scholars to understand how conclusions are reached.
3. Infrastructure gaps: Many Islamic countries lack high-quality observatories, computational resources, or stable internet connections.
4. Ethical oversight: Without clear governance, AI might be seen as encroaching upon human religious authority³⁴.

Overcoming these challenges requires collaboration between astronomers, AI engineers, and Islamic jurists, ensuring that both technical reliability and religious legitimacy are preserved.

AI’s unique strength is its capacity to function as an epistemic bridge between human observation and computational prediction. By continuously correlating empirical

³² Floridi, L., & Cowan, T. (2021). How to design AI for social good: Seven essential factors. *AI & Society*, 36(1), 17–31. <https://doi.org/10.1007/s00146-020-00944-1>

³³ Kordi, M. (2022). *Artificial intelligence applications in modern astronomy: Opportunities and challenges*. *Advances in Space Science*, 45(2), 112–129. <https://doi.org/10.1016/j.advsci.2022.04.003>

³⁴ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). Islamic astronomy and the integration of modern science: A study of falak application in the digital era. *Journal of Islamic Science and Technology*, 12(3), 45–59.

data with theoretical models, AI embodies the principle of *‘ilm al-yaqīn* (knowledge based on evidence). In the context of Islamic calendrical science, this means that AI can mediate between *hisab* (rational certainty) and *rukyat* (empirical verification), facilitating a new form of digital *ijtihād* collective reasoning augmented by computational intelligence.

Integrating Hisab and Rukyat through AI Frameworks and Ethical Considerations

For more than a millennium, Muslim astronomers and jurists have debated the relationship between *hisab* (astronomical calculation) and *rukyat* (empirical sighting) in determining the start of Hijri months. Historically, both approaches evolved in parallel but rarely converged under a unified methodology. While *hisab* provides predictive precision, *rukyat* retains theological authority rooted in the Prophet’s hadith: “*Fast when you see it (the moon) and break your fast when you see it.*” The resulting tension reflects a larger epistemological divide between rational empiricism and scriptural literalism³⁵.

In the digital era, Artificial Intelligence (AI) emerges as a promising intermediary that can unite both paradigms through a structured and verifiable framework. AI’s ability to model uncertainty, learn from empirical data, and provide interpretable results makes it uniquely positioned to mediate between *hisab*’s scientific rigor and *rukyat*’s evidential authenticity. However, for such integration to gain religious and institutional legitimacy, it must adhere to the principles of transparency, accountability, and interpretability values resonant with Islamic ethics of *‘adl* (justice) and *amānah* (trust).

The integration of *hisab* and *rukyat* through AI can be conceptualized as a three-layered model, each representing a distinct dimension of decision-making

Scientific–Computational Layer (Hisab–AI Engine) At this layer, astronomical data (moon’s altitude, elongation, illumination, azimuth difference) are processed using AI algorithms such as deep regression networks or Gaussian process models to produce visibility probabilities³⁶. The outputs are numerical and probabilistic, representing the *scientific likelihood* of sighting.

Empirical–Observational Layer (Rukyat–AI Validation): This

³⁵ King, D. A. (1983). *Astronomy in the service of Islam*. Variorum Reprints.

³⁶ Kordi, M. (2022). Artificial intelligence applications in modern astronomy: Opportunities and challenges. *Advances in Space Science*, 45(2), 112–129.

layer collects real-time visual data from global observatories and local observers using computer vision tools. AI validates whether the observed object matches the geometrical and photometric profile of the crescent moon³⁷. These verified data points are stored in a centralized database that refines the predictive model.

Decision–Juristic Layer (Shariah Governance and Ijtihād): Religious authorities access AI-generated reports through interpretable dashboards that visualize confidence intervals, sky clarity, and verified sighting zones. Scholars may deliberate over the data in line with *fiqh al-rukyat* principles, allowing AI to inform but not dictate final rulings³⁸. This layered structure maintains the epistemological balance between human judgment and machine intelligence. AI functions as *mu'tn al-ijtihad*—an assistive instrument of reasoning that amplifies human understanding without replacing it. The computational backbone of the proposed framework is a hybrid AI engine combining Machine Learning (ML) for predictive analytics of visibility, Computer Vision (CV) for image-based validation, and Explainable AI (XAI) for interpretability and transparency.

These components work synergistically to transform the classical *hisab* pipeline into a data-driven feedback system. For example, a *Gradient Boosting Regressor* may first predict visibility based on *hisab* parameters. Then, a CNN-based model evaluates the corresponding photographic data. If a discrepancy arises, the algorithm recalibrates its internal weighting scheme, thus continuously improving prediction reliability^{39 40}. For cross-disciplinary interoperability, the system requires a semantic ontology that defines and connects key terms such as *hilāl visibility*, *sunset altitude*, *angular separation*, and *rukyat success probability*. Using the Web Ontology Language (OWL), AI systems can encode these definitions to ensure consistent interpretation across observatories and national jurisdictions⁴¹. This structure enables *interoperable reasoning*: when AI encounters ambiguous data, it can reference encoded definitions to make context-aware

³⁷ Li, Z., Chen, H., & Zhou, W. (2021). Deep learning approaches in astronomical image analysis. *Astrophysical Computing Journal*, 38(4), 301–319.

³⁸ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). Islamic astronomy and the integration of modern science: A study of falak application in the digital era. *Journal of Islamic Science and Technology*, 12(3), 45–59.

³⁹ Chen, T., & Guestrin, C. (2016). XGBoost: A scalable tree boosting system. *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 785–794.

⁴⁰ Zhang, Q., Luo, T., & Lin, Y. (2023). Low-light image enhancement using deep convolutional networks. *IEEE Transactions on Image Processing*, 32(6), 2554–2568.

⁴¹ Berners-Lee, T., Hendler, J., & Lassila, O. (2001). *The semantic web*. *Scientific American*, 284(5), 28–37.

judgments aligned with Islamic astronomical terminology.

Given the importance of trust and transparency in religious decision-making, blockchain technology can be used to log each sighting event and AI decision in an immutable ledger. This ensures that every data point—from observation images to algorithmic output—can be independently verified, fostering institutional confidence and preventing tampering⁴². A “smart contract” protocol could automate data validation workflows, triggering review processes when conflicting evidence arises.

Islamic knowledge tradition classifies epistemic sources into three domains: *naqlī* (revealed), *‘aqlī* (rational), and *hissī* (empirical). AI, by synthesizing *hisab* (rational) and *rukyat* (empirical), functions as a technological bridge that aligns with the Islamic epistemic triad. It does not introduce new revelation but strengthens the human capacity to discern reality (*ḥaqīqah*)⁴³. In *usūl al-fiqh* (Islamic legal methodology), when new instruments aid certainty (*yaqīn*) without violating revealed texts, their use is *mubāḥ* (permissible) or even *mandūb* (recommended)⁴⁴. AI systems thus can be seen as extensions of rational inquiry, not as replacements for human testimony. This reconciles theological conservatism with technological progress.

While AI can automate the technical aspects of lunar visibility calculation, the final authority remains with recognized juristic bodies, such as national moonsighting committees or global fiqh councils. This arrangement respects the principle of *wilāyah al-‘ilmiyyah* (knowledge-based authority), ensuring that machines serve as advisory tools within a human-centered ethical framework⁴⁵. In classical jurisprudence, *ijma’* (consensus) arises when qualified scholars agree on a ruling. AI can facilitate a digital form of *ijma’*, where verified data, visibility maps, and probabilistic outputs are transparently shared across borders. Scholars reviewing the same empirical evidence can reach convergence more efficiently, turning data harmonization into a means for global

⁴² Al-Qudah, M., & Rahman, M. F. (2022). IoT-based collaborative observation networks for lunar visibility studies. *Journal of Astronomical Systems Engineering*, 19(3), 201–219.

⁴³ Al-Faruqi, I. R. (1982). *Islamization of knowledge: General principles and work plan*. International Institute of Islamic Thought.

⁴⁴ Kamali, M. H. (2003). *Principles of Islamic jurisprudence* (3rd ed.). Islamic Texts Society.

⁴⁵ Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). Islamic astronomy and the integration of modern science: A study of falak application in the digital era. *Journal of Islamic Science and Technology*, 12(3), 45–59.

ijtihād jamāʿī (collective reasoning).

AI applications in religious domains must align with *maqāṣid al-sharīʿah*—the higher objectives of Islamic law: preservation of faith (*dīn*), intellect (*ʿaql*), life (*nafs*), lineage (*nasl*), and property (*māl*)⁴⁶. In the context of the Hijri calendar, these objectives manifest as Faith-Upholding trust in the authenticity of religious observance, Intellect-Utilizing rational and scientific means responsibly, Community welfare-Minimizing confusion and division in worship times. When designed ethically, AI can advance all three objectives by improving accuracy and unifying Muslim practice globally.

Transparency (*bayān*) is an ethical imperative in both AI governance and Islamic jurisprudence. The Explainable AI (XAI) paradigm ensures that AI’s decision-making process can be traced and interpreted by human experts⁴⁷. In a Shariah context, this aligns with the Qur’anic command to “bring clear proof” (*bayyinah*), reinforcing that automation should never obscure responsibility. AI outputs must be accompanied by confidence intervals, input data logs, and rationale summaries that allow jurists to assess the validity of results. Islamic ethics emphasize the moral agency of humans (*taklīf*). Therefore, AI systems in astronomy should remain non-autonomous—operating under *ḥisbah* (supervision) by qualified experts. This corresponds to global AI ethics principles such as “human-in-the-loop” design⁴⁸. In practice, this means AI tools can suggest, but cannot declare, the beginning of a month; that prerogative rests with human authorities. Given the global diversity of Muslim communities, ethical AI must be inclusive. Training datasets should incorporate observations from multiple latitudes and environments Arabian deserts, Indonesian tropics, African plateaus to prevent geographical bias. Inclusion ensures that AI predictions do not privilege certain regions or atmospheric conditions over others⁴⁹.

Achieving reliable AI integration requires cooperation between Scientific

⁴⁶ Auda, J. (2008). *Maqasid al-Shariah as philosophy of Islamic law: A systems approach*. International Institute of Islamic Thought.

⁴⁷ Arrieta, A. B., Díaz-Rodríguez, N., Ser, J. D., Bennetot, A., Tabik, S., Barbado, A., ... & Herrera, F. (2020). *Explainable artificial intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI*. *Information Fusion*, 58, 82–115.

⁴⁸ Floridi, L., & Cowan, T. (2021). How to design AI for social good: Seven essential factors. *AI & Society*, 36(1), 17–31.

⁴⁹ Zou, J., & Schiebinger, L. (2018). AI can be sexist and racist—it’s time to make it fair. *Nature*, 559(7714), 324–326.

institutions (e.g., observatories, meteorological agencies), Religious authorities (e.g., national fatwa councils, OIC), and Technological organizations (AI developers, data engineers). A joint framework could be established under the Organisation of Islamic Cooperation (OIC) or the Islamic Crescent Observation Project (ICOP) to manage standardization, certification, and data sharing. A standardized *AI-Shariah Compliance Protocol (AISCP)* could define: 1. Model verification procedures, 2. Ethical audit trails, 3. Juristic review steps prior to public calendar release. Such institutionalization would emulate successful cross-sector standards like the “Halal Blockchain” certification in finance⁵⁰, ensuring both technological and religious integrity.

The culmination of this integration framework is a coherent epistemological synthesis where: 1, *Hisab* contributes computational certainty, 2. *Rukyat* ensures experiential authenticity, 3. AI mediates between them through interpretive analytics, 4. Religious authorities maintain final moral responsibility. This model transforms the longstanding dichotomy into a mutually reinforcing triad, promoting not only scientific precision but also theological unity. Such integration echoes the historical precedent of medieval Muslim astronomers like al-Bīrūnī and Ibn Shāṭir, who harmonized observation and theory long before modern science formalized the method⁵¹

Toward a Unified Global Hijri Calendar: Implementation, Implications and Conclusion

The integration of Artificial Intelligence (AI) into the Hijri calendrical system must begin with a clear strategic vision anchored in both scientific precision and Shariah legitimacy. The overarching objective is not to replace traditional mechanisms but to create a technologically assisted decision framework that promotes *unity of practice* across the Muslim world. The success of such an initiative depends on multilevel governance combining national, regional, and transnational coordination mechanisms under a shared policy umbrella.

A feasible starting point is the establishment of an International Hijri Calendar

⁵⁰ Hassan, R., Ismail, S., & Azmi, I. M. (2020). Blockchain and halal certification: A conceptual framework for trust and transparency. *Journal of Islamic Finance*, 9(2), 45–57.

⁵¹ King, D. A. (1983). *Astronomy in the service of Islam*. Variorum Reprints.

Coordination Council (IHCCC), modeled on hybrid organizations such as the International Astronomical Union (IAU) and the Organisation of Islamic Cooperation (OIC). The IHCCC would function as an interdisciplinary platform connecting astronomers, AI engineers, Shariah jurists, and policymakers. Its mandate would include: Developing shared standards for lunar data acquisition and validation, Setting ethical and transparency benchmarks for AI-based decision tools, Facilitating consensus (*ijma'*) among national moonsighting authorities; and Overseeing interoperability between AI algorithms and local *falak* observatories⁵².

This governance model ensures that the technological modernization of the Hijri calendar remains institutionally accountable and religiously legitimate. A phased approach can enhance scalability and minimize socioreligious resistance.

Phase 1 Infrastructure and Data Standardization: This phase focuses on establishing a global observational data repository, integrating datasets from meteorological satellites, local observatories, and historical *rukyat* archives. Standardized metadata formats such as the Astronomical Data Query Language (ADQL) and Open Data Cube (ODC) frameworks can ensure interoperability⁵³. **Phase 2 AI Model Development and Validation:** AI models including *convolutional neural networks* (CNNs) for lunar imaging and *Bayesian hierarchical models* for visibility probability—are developed using these datasets. Validation involves cross-referencing AI predictions with human sighting records. Ethical approval processes, similar to research ethics boards, would review algorithmic transparency and bias metrics⁵⁴. **Phase 3, Shariah Review and Juristic Calibration:** Once validated, the AI outputs undergo *fiqh al-rukyat* review. Scholars assess whether predictive and visual outcomes align with Islamic evidentiary principles, emphasizing *yaqīn* (certainty) and *bayyinah* (clear proof). The Shariah board may specify acceptable confidence intervals (e.g., >95% visibility probability) before declaration. **Phase 4, Public Integration and Policy Adoption:**

⁵² Hashim, N. H., Ibrahim, A. S., & Ahmad, M. Y. (2020). Islamic astronomy and the integration of modern science: A study of *falak* application in the digital era. *Journal of Islamic Science and Technology*, 12(3), 45–59.

⁵³ Buneman, P., Khanna, S., & Tan, W. C. (2001). Why and where: A characterization of data provenance. *Lecture Notes in Computer Science*, 1973, 316–330.

⁵⁴ Arrieta, A. B., Díaz-Rodríguez, N., Ser, J. D., Bennetot, A., Tabik, S., Barbado, A., ... & Herrera, F. (2020). *Explainable artificial intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI*. *Information Fusion*, 58, 82–115.

Governments can integrate the system through official calendars, synchronized digital platforms, and mobile applications. National observatories can link to the central AI repository via secure cloud-based networks, ensuring real-time updates for global synchronization⁵⁵.

Figure 9. Phased Implementation Framework for AI-Based Hijri Calendar
(Illustration description: Flowchart showing sequential phases—Data Standardization → AI Model Development → Shariah Review → Policy Adoption—connected by feedback loops for continuous validation.) The infrastructure should combine edge computing, satellite integration, and secure data pipelines. Edge computing devices installed in observatories can preprocess lunar imagery locally, reducing latency and dependence on centralized servers. Satellite imaging, particularly from low-Earth orbit sensors, provides cloud-independent data for regions with adverse weather. Blockchain-based audit trails ensure immutable logging of each observation and decision, promoting transparency and public trust⁵⁶.

Complementary AI visualization dashboards can present *rukyat* likelihood maps, cloud density overlays, and historical trend analysis in accessible formats for religious councils and the public alike. No technological transformation can succeed without human competence and moral oversight. Therefore, the IHCCC should sponsor a Capacity-Building Program in AI-Falak Integration, training ‘*ulamā*’ and astronomers in; Data ethics and interpretability, Model validation and uncertainty communication, and Ethical AI deployment under *maqāṣid al-sharī‘ah* frameworks⁵⁷. An AI Ethics Board should be instituted within the IHCCC to audit models for bias, reliability, and compliance with religious norms. This reflects the dual accountability structure of *ḥisbah* (oversight for public good) and *amānah* (trust).

Global Implications and Policy Perspectives

⁵⁵ Kordi, M. (2022). *Artificial intelligence applications in modern astronomy: Opportunities and challenges*. *Advances in Space Science*, 45(2), 112–129.

⁵⁶ Al-Qudah, M., & Rahman, M. F. (2022). IoT-based collaborative observation networks for lunar visibility studies. *Journal of Astronomical Systems Engineering*, 19(3), 201–219.

⁵⁷ Auda, J. (2008). *Maqasid al-Shariah as philosophy of Islamic law: A systems approach*. International Institute of Islamic Thought.

The harmonization of *hisab* and *rukyat* through AI has profound socio-religious implications. Historically, calendar discrepancies have fragmented global Muslim observance, leading to differing Eid dates and fasting schedules. AI-based harmonization promises to strengthen global Muslim unity while preserving theological diversity. AI does not abolish local traditions; instead, it enriches them through evidence-based coordination. For instance, AI-driven visibility models can account for regional atmospheric differences, allowing flexibility within a unified framework. This addresses both the *urf* (customary practice) of local communities and the global *ummah*'s aspiration for unity⁵⁸.

Furthermore, transparent AI documentation fosters public trust in astronomical predictions turning calendar determination into a participatory scientific-religious dialogue rather than a contest of authority. Beyond religious significance, a unified Hijri calendar has economic and administrative benefits. Islamic financial systems, international pilgrimage management (Hajj, Umrah), and global halal industries depend on precise and predictable Hijri dates. Calendar inconsistencies impose costs disrupted travel logistics, scheduling conflicts, and transactional uncertainty in date-sensitive contracts. AI-enabled predictability allows governments and institutions to plan religious holidays years in advance with statistically validated accuracy. This improves macroeconomic stability, especially in Muslim-majority economies where lunar events influence market cycles⁵⁹.

At a diplomatic level, the adoption of an AI-assisted Hijri calendar could symbolize technological leadership within the Islamic world. It positions Muslim nations as active contributors to global AI ethics and astronomy, countering narratives that religion and science are incompatible. Moreover, a unified calendar fosters cultural diplomacy a shared timekeeping system becomes a soft-power symbol of Muslim unity akin to the Gregorian calendar's global adoption for civil use. The project aligns with the UN Sustainable Development Goals (SDG 17) on partnerships for technological and institutional cooperation. Every paradigm shift invites resistance. Concerns may arise

⁵⁸ Kamali, M. H. (2003). *Principles of Islamic jurisprudence* (3rd ed.). Islamic Texts Society.

⁵⁹Rahman, A. A., & Hassan, M. K. (2021). *Economic implications of lunar-based calendrical discrepancies in Muslim economies*. *Journal of Islamic Economic Studies*, 29(1), 77–98.

over: Technological determinism fear that AI decisions will override human and scriptural authority; Data sovereignty suspicion that centralized data control undermines national autonomy; Ethical opacity lack of understanding of how AI algorithms reach conclusions.

Mitigation requires transparent governance: AI outputs must remain advisory, not declarative. Open-source code repositories and algorithmic audits enhance credibility⁶⁰. Juristic oversight ensures decisions reflect *maqāṣid al-sharī'ah*. Proactive communication campaigns public seminars, mosque-based workshops, and multilingual media can contextualize AI's supportive role, demystifying technology through religious literacy.

To sustain innovation, the IHCCC should promote AI–Falak Research Clusters in universities, focusing on: *Astroinformatics* for lunar data analysis, *Ethical AI* grounded in Islamic epistemology, *Human–AI collaboration* for juristic decision support. Joint funding mechanisms with OIC and UNESCO could incentivize cross-border research. Such collaborations cultivate intellectual ecosystems where faith, science, and technology coevolve. Unlike static calculation methods, AI thrives on continuous learning. Future models can incorporate *reinforcement learning* to improve predictions after each lunar cycle, integrating corrections from verified *rukyat* reports. This cyclical feedback mimics the *mujaddid* (periodic renewal) principle in Islamic thought where knowledge evolves while preserving foundational truths⁶¹. Incorporating contextual reasoning allows AI to distinguish between exceptional cases like optical illusions, atmospheric distortions, or false-positive sightings enhancing reliability.

Developing citizen-science initiatives can democratize lunar observation. Mobile apps linked to the global database could allow individuals to upload images or visibility reports, verified by AI algorithms. This participatory model merges *'ilm al-falak* with civic engagement, making calendar determination a communal act of digital worship. Such integration echoes the Qur'anic encouragement to “reflect on the creation

⁶⁰ Arrieta, A. B., Díaz-Rodríguez, N., Ser, J. D., Bennetot, A., Tabik, S., Barbado, A., ... & Herrera, F. (2020). *Explainable artificial intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI*. *Information Fusion*, 58, 82–115

⁶¹ Al-Faruqi, I. R. (1982). Islamization of knowledge: General principles and work plan. International Institute of Islamic Thought.

of the heavens and the earth”⁶², situating AI-enabled astronomy as both scientific and devotional practice. The vision of a Global AI-Integrated Hijri Calendar transcends mere computational innovation it represents a new paradigm of knowledge integration between revelation and reason. By aligning *hisab* and *rukyat* through AI mediation, Muslim societies can overcome centuries-old disputes with a solution that is both *‘ilmī* (scientific) and *shar‘ī* (lawful).

From a policy perspective, this transformation requires sustained collaboration among religious scholars, astronomers, data scientists, and policymakers, anchored by shared ethical commitments. The proposed IHCCC and AI-Shariah protocols offer practical roadmaps to realize this vision without undermining the theological sanctity of lunar observation. As the world advances toward intelligent automation, Islamic astronomy can reclaim its historic role as a bridge between science and spirituality. Through AI, the sighting of the *hilāl* (new moon) becomes not only a ritual moment but also a symbol of global unity, informed faith, and technological wisdom a harmonization of heaven’s signs and human intellect.

CONCLUSION

The study demonstrates that the integration of Artificial Intelligence (AI) into the determination of the Hijri calendar represents not only a scientific advancement but also a strategic pathway toward harmonizing faith-based traditions and digital innovation. By leveraging AI’s capabilities in astronomical data processing, image recognition, and predictive modeling, Islamic astronomy (*‘ilm al-falak*) can overcome long-standing limitations of manual observation and localized computation. AI provides a framework that enhances *hisab* accuracy while maintaining the essential spiritual and epistemological role of *rukyat* as a means of religious validation.

The research underscores that a unified global Hijri calendar is technologically feasible through AI-assisted modeling of lunar visibility, atmospheric conditions, and observational probabilities. However, it also emphasizes that technical precision alone is

⁶² (Qur’an 3:191)

insufficient. The success of such a system depends on theological endorsement, institutional trust, and ethical governance that align technological innovation with Islamic jurisprudence (*fiqh al-awqāt*). Hence, AI should be seen not as a replacement for traditional methods but as a mediating instrument that bridges the epistemic divide between *hisab* and *rukyat* communities. From a policy perspective, adopting AI-driven systems for lunar determination requires the establishment of internationally coordinated frameworks, such as through the Organization of Islamic Cooperation (OIC) or regional bodies like MABIMS. These frameworks should set shared data standards, visibility criteria, and AI transparency protocols. Furthermore, collaborative research between astronomers, data scientists, and *ulama* can foster a more inclusive and legitimate approach to timekeeping in Islam.

Ethically, the use of AI in religious observances must respect the principle of *maqāsid al-sharī‘ah*, ensuring that the technology serves communal unity (*ittihād al-ummah*) and spiritual coherence rather than mere computational efficiency. Therefore, the future of Islamic calendrical science lies in co-evolution rather than competition between human observation and machine intelligence.

In conclusion, the harmonization of *hisab* and *rukyat* through AI exemplifies how digital technologies can be ethically aligned with sacred traditions. The successful realization of a global Hijri calendar will depend on interdisciplinary collaboration, adaptive policy frameworks, and sustained dialogue between science and faith. Through such synergy, the Muslim world can move toward a digitally unified, theologically sound, and globally recognized lunar calendar a milestone that reflects both scientific excellence and spiritual unity in the digital era.

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