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Verification of *Hilāl* Image Using AI-Based Web Tool in Aceh Jaya

Ravik Walhidayah[1*], Ismail Ismail[2]

[1] Universitas Islam Negeri Sultanah Nahrasiyah Lhokseumawe, Indonesia
[2] Universitas Islam Negeri Sultanah Nahrasiyah Lhokseumawe, Indonesia
* Corresponding Author, email: ravikwalhidayah2002@gmail.com

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Abstract

The determination of Hijri month beginnings is frequently disputed, particularly due to the subjective nature of the *ru'yah* (visual sighting) method, which is affected by observer bias and atmospheric variability. This study addresses a contested *hilāl* sighting in Aceh Jaya for 1 Zulhijjah 1446 AH, where a photograph led to uncertainty in official determination. To mitigate misinterpretation, an artificial intelligence (AI)-based public website utilizing Google's Teachable Machine was developed and tested. Descriptive analysis was conducted on two disputed photographic samples from the event. The AI model, trained for crescent (*hilāl*) image classification, consistently identified both samples as non-*hilāl* with a confidence exceeding 97%. The findings indicate the images were likely artifacts or noise rather than genuine crescent sightings. The research demonstrates that AI platforms provide reliable, objective support in *hilāl* verification, enhancing the standardization and credibility of Hijri calendar determinations for religious and scientific authorities.

Keywords: hijri calendar, *hilāl* verification, artificial intelligence, *ru'yah*

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Penetapan awal bulan Hijriah sering menjadi perdebatan, terutama karena metode *ru'yah* (observasi visual) sangat dipengaruhi oleh subjektivitas pengamat dan variabilitas kondisi atmosfer. Studi ini membahas perselisihan dalam penetapan *hilāl* di Aceh Jaya untuk 1 Zulhijjah 1446 H, di mana sebuah foto menimbulkan ketidakpastian dalam keputusan resmi. Untuk meminimalkan kemungkinan salah tafsir, dikembangkan dan diuji sebuah situs web publik berbasis kecerdasan buatan (AI) menggunakan Google Teachable Machine. Analisis deskriptif dilakukan terhadap dua foto yang dipermasalahkan dari peristiwa tersebut. Model AI yang dilatih untuk klasifikasi citra *hilāl* secara konsisten mengidentifikasi kedua foto sebagai bukan *hilāl* dengan tingkat keyakinan di atas 97%. Temuan ini menunjukkan bahwa gambar tersebut kemungkinan hanyalah artefak atau noise, bukan penampakan *hilāl* sejati. Penelitian ini membuktikan bahwa verifikasi citra berbasis AI mampu memberikan dukungan yang andal dan objektif dalam validasi *hilāl*, serta meningkatkan standarisasi penetapan kalender Hijriah bagi otoritas agama dan ilmuwan.

Kata Kunci: kalender Hijriah, verifikasi *hilāl*, kecerdasan buatan, metode *ru'yah*

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A. Introduction

In May 2025, a significant controversy arose in Aceh Jaya, Indonesia, concerning the sighting of the new crescent moon (*hilāl*) marking 1 Zulhijjah 1446 AH. During an official *ru'yah* (moon-sighting) session at Kuala Doe Beach, Gampong Lhok Geulumpang, Setia Bakti District, observers initially reported no visible *hilāl*. Consequently, the *itsbāt* (confirmation) session concluded that the crescent had not been sighted, and the start of the new month could not yet be declared. However, later that evening, at approximately 19:20 GMT+7, one of the observers claimed to have captured a photograph depicting a faint shape near the western horizon that was interpreted as the *hilāl*. The image, circulated widely on social media with a marked arrow indicating the suspected crescent, sparked rapid public attention and claims that the *hilāl* had been successfully observed in Aceh Jaya.[1]

The incident quickly developed into a national debate regarding the credibility of photographic evidence in religious astronomy. While some parties accepted the image as valid proof of the *hilāl's* visibility, others rejected it, arguing that the figure was merely optical noise or an artifact produced by the camera lens. In response to these conflicting interpretations, the Aceh *Shar'iyyah* Court, under the Directorate General of the Religious Judiciary of the Supreme Court of the Republic of Indonesia, convened a second *itsbāt* session to reassess the observation. The session ultimately endorsed the *ru'yah* report and officially declared that the *hilāl* had been sighted at 18:48 GMT+7, prompting the recognition of 1 Zulhijjah 1446 AH.[2] This case exemplifies the persistent challenges of subjectivity, technological limitation, and verification in determining the beginning of Islamic lunar months, an issue that continues to underscore the need for more objective, technology-assisted methods, especially on AI-based technology, in contemporary *ru'yah* practices.

Recent literature highlights an emerging convergence between astronomical science, Islamic jurisprudence, and artificial intelligence (AI) in addressing long-standing challenges in determining the beginning of the Hijri month. Murad Al-Rajab et al. (2023) proposed the use of machine learning algorithms, specifically Random Forest and Support Vector Machine, to predict the visibility of the new crescent moon with high accuracy, demonstrating that AI can process complex astronomical variables such as altitude, elongation, and atmospheric conditions more efficiently than traditional empirical models.[3] Similarly, Lairgi (2025) refined the ODEH visibility criterion through the *Manazel* model using logistic regression trained on 13 years of lunar observation data, achieving 98.83% prediction accuracy and offering an adaptable framework for diverse climatic conditions.[4]

In the Indonesian context, Rofiuddin and Ardliansyah (2024) emphasized that AI should serve as an assistive instrument within the framework of *fiqh* and astronomy, reinforcing that technological accuracy must coexist with theological legitimacy.[5] Furthermore, Rudi Hartono and Muhammad Yunus (2025) argued that the synthesis of *ḥisāb* and *ru'yah* reflects not merely

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[1] "Unik, Hilal terlihat setelah 2 kali sidang dengan 2 permohonan," Mahkamah Syar'iyah Aceh (ms-aceh.go.id), May 27, 2025, https://ms-aceh.go.id/berita-se-aceh/item/15006-unik%2C-hilal-terlihat-setelah-2-kali-sidang-dengan-2-permohonan.

[2] Direktori Putusan et al., *Direktori Putusan Mahkamah Agung Republik Indonesia*, 2025.

[3] Murad Al-Rajab et al., "Predicting New Crescent Moon Visibility Applying Machine Learning Algorithms," *Scientific Reports* 13, no. 1 (2023): 6674, https://doi.org/10.1038/s41598-023-32807-x.

[4] Yassir Lairgi, "When Astronomy Meets AI: Manazel For Crescent Visibility Prediction in Morocco," arXiv:2503.21634, preprint, arXiv, March 27, 2025, https://doi.org/10.48550/arXiv.2503.21634.

[5] Ahmad Adib Rofiuddin and Moelki Fahmi Ardliansyah, "The Utilization of Artificial Intelligence in Determining the Beginning of Islamic Calendar in Indonesia," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 10, no. 2 (2025): 82–94, https://doi.org/10.30596/jam.v10i2.16803.

methodological dualism but epistemological complementarity, requiring integration under the principles of *maqāṣid al-sharīʿah* and collective *ijtihād*. Collectively, these studies underscore a paradigm shift toward Islamic techno-astronomy, wherein AI serves as a decision-support tool that enhances the objectivity, reliability, and global synchronization of lunar calendar determinations without displacing the religious essence of *ru'yah*.

Building upon the recent integration of artificial intelligence in astronomical observation, this study aims to evaluate the effectiveness of an AI-based verification system in addressing interpretive ambiguities during *ru'yah al-hilāl* events. The research specifically examines the contested crescent sighting in Aceh Jaya for 1 Zulhijjah 1446 AH, in which a circulated photograph caused public and institutional uncertainty over the validity of the reported observation. To reduce subjectivity and observer bias, a web-based platform utilizing Google's Teachable Machine was developed to assist in crescent image verification. The AI model was trained through supervised learning to distinguish genuine lunar crescents from atmospheric or optical artifacts. This approach reflects an interdisciplinary framework that integrates astronomical computation, image classification technology, and Islamic legal verification, offering a structured, empirical basis for validating *ru'yah* claims.

The analysis applied descriptive evaluation to two photographic samples from the Aceh Jaya event, both of which had been publicly claimed as evidence of *hilāl* visibility. The AI model consistently classified both images as non-*hilāl*, with a prediction confidence level exceeding 97 percent, indicating that the shapes captured were more likely optical noise or camera artifacts rather than an actual crescent. These findings substantiate the reliability and objectivity of AI-assisted verification in minimizing perceptual bias among human observers. More importantly, the study demonstrates that integrating AI platforms into *ru'yah* practices can significantly enhance the credibility, transparency, and standardization of Hijri month determinations. In doing so, it contributes to the emerging discourse on Islamic techno-astronomy, where technological tools operate not as replacements for human observation, but as decision-support mechanisms that uphold both scientific rigor and the theological integrity of lunar calendar verification.

B. Method

This study employs a descriptive analytical approach, using Artificial Intelligence (AI) technology as the primary instrument for verifying *hilāl* imagery. The data consisted of three photographic samples taken during the *ru'yah hilāl* for 1 Zulhijjah 1446 AH on May 27, 2025, at Kuala Doe Beach, Gampong Lhok Geulumpang, Setia Bakti District, Aceh Jaya Regency, Aceh Province. These photos were selected because, on that date, a rare event occurred in which the *itsbāt hilāl* session was convened twice in one day due to differing observation reports from the field. The three images were subsequently analyzed using a web-based platform integrated with an AI model developed through Teachable Machine.

In this study, the primary data consist of three photographs taken during the *ru'yah* process, while the secondary data are obtained from reports published on the official website of the Aceh Sharia Court. The focus of the analysis is on the primary data, which were directly tested using the AI model that had been developed. The model had previously been trained with a dataset containing both *hilāl* and non-*hilāl* images, enabling it to automatically classify uploaded images. The research procedure involved uploading the three photo samples to the *hilāl* image analysis website. The AI system then processed the data directly within the web browser to classify whether each photograph contained a *hilāl* or not, and the output was presented in the form of prediction results along with a certain level of confidence. The findings from this analysis were interpreted descriptively to evaluate the consistency and reliability of the system in detecting the presence of the new moon. Verification was conducted by comparing the AI-generated output with field observation reports and the official decisions from the *itsbāt* session.

C. Result and Discussion

1. Bridging Tradition and Technology: Challenges and Innovations in *Hilāl* Observation for the Hijri Calendar

The Hijri calendar, used by Muslims across the world, is a purely lunar system that governs the timing of major Islamic rituals and observances. Unlike the solar-based Gregorian calendar, which depends on the Earth's revolution around the Sun, the Hijri calendar follows the Moon's orbit around the Earth. Consequently, it comprises 12 months of approximately 29 to 30 days each, producing a year that is shorter by about 11 days. The beginning of each month is determined through either *ḥisāb* (astronomical calculation) or *ru'yah* (visual observation of the new crescent moon).[6] The *ḥisāb* method employs precise mathematical models to compute the Moon's position, whereas *ru'yah* emphasizes empirical confirmation through direct visual sighting after *ijtimāʿ* (conjunction). These dual approaches illustrate the rich interplay between scientific reasoning and religious tradition in the development of Islamic astronomy.

Although the *ru'yah* method appears conceptually simple, requiring only the observation of the first visible crescent (*hilāl*), its practical application is far more complex. Several factors contribute to the difficulty of *ru'yah*, including atmospheric conditions, light pollution, topographical obstructions, and human visual limitations in distinguishing the delicate crescent against the evening twilight. These constraints often result in inconsistent or conflicting reports among observers. Despite such challenges, *ru'yah* continues to be viewed as the most authentic means of lunar verification because of its strong theological basis in the prophetic tradition. However, ensuring the scientific credibility and juridical reliability of *ru'yah* requires balancing the precision of modern astronomy with the trustworthiness of human observation.[7]

The *hilāl* phenomenon has long been a subject of scientific inquiry and religious discourse. It becomes especially significant at the start of the months of Ramadan, Shawwal, and Zulhijjah, when accurate timing directly determines the observance of fasting, Eid celebrations, and pilgrimage rituals. During these periods, communities across the Muslim world engage in *ru'yah* activities, often involving government institutions, astronomical societies, and local observers. The process sometimes takes on an informal competitive dimension, as various groups seek to be the first to confirm the new crescent's appearance. These dynamic highlights both the social importance of lunar observation in Islam and the continuing challenge of achieving consensus across different regions and methodological schools. Discrepancies frequently arise not only from varying

[6] Zulfian Wanandi et al., "Reforming Lunar Calculations in Indonesia: The Academic Legacy of Muhammad Basiuni Imran," *Al-Hilal: Journal of Islamic Astronomy* 7, no. 1 (2025): 89–100, https://doi.org/10.21580/al-hilal.2025.7.1.25950.

[7] Khairul Anaam, "Utilization of Radio Telescopes in Determining the Beginning of the Islamic Calendar," *Al-Hilal: Journal of Islamic Astronomy* 6, no. 2 (2024): 177–98, https://doi.org/10.21580/al-hilal.2024.6.2.23416.

observational success but also from differing interpretations of *fiqh* (Islamic jurisprudence) and criteria for visibility.

To ensure the reliability of *ru'yah al-hilāl*, several critical factors must be addressed. Environmental conditions, such as cloud cover, humidity, and pollution, can obscure visibility and distort perception. Geographical considerations also play an important role: observation sites with clear western horizons, higher elevations, and minimal artificial lighting provide the best chance for successful sightings. In addition, the use of technological instruments, including telescopes, high-resolution cameras, and digital imaging systems, can greatly enhance the accuracy of detection by amplifying the faint light of the crescent.[8] Equally important, however, are the psychological factors influencing observers. Strong anticipation or cognitive bias can lead individuals to misinterpret other phenomena, such as thin clouds or atmospheric reflections, as the *hilāl*. These subjective limitations underscore the necessity of methodological refinement and technological support to validate *ru'yah* results within both scientific and religious frameworks.[9]

In Indonesia, the determination of Ramadan, Shawwal, and Zulhijjah follows a hybrid model combining both *ḥisāb* and *ru'yah*. The *ḥisāb* approach, based on astronomical computation, adheres to the *imkān al-ru'yah* MABIMS criteria, which define visibility when the Moon's altitude reaches at least 3° and its elongation (angular separation from the Sun) is 6.4° or more.[10] The *ru'yah* method, meanwhile, requires direct field observation to confirm the appearance of the crescent. Both approaches are formally integrated within Indonesia's *itsbāt* (official confirmation session), through which the government announces the beginning of the Hijri months. In practice, *ḥisāb* serves as the predictive foundation, while *ru'yah* provides empirical validation. When both converge under the MABIMS standard, the month's commencement can be declared with institutional consensus.[11]

2. The Complexity of *Hilāl* Observation: Methodological, Technical, and Socio-Religious Dimensions in the Determination of the Hijri Month

The determination of the beginning of the Hijri month has long been a recurring challenge within Islamic calendrical practice, especially during the months of Ramadan, Shawwal, and Zulhijjah, when accurate timing directly affects the performance of key religious observances such as fasting, Eid celebrations, and pilgrimage. In principle, two main methods are employed to establish the start of a new lunar month: the *ḥisāb* method, which is based on astronomical calculation, and the *ru'yah* method, which involves direct visual observation of the thin crescent moon (*hilāl*). While *ḥisāb* provides predictive certainty through mathematical modeling of celestial mechanics, *ru'yah* relies on empirical confirmation that often faces practical difficulties. Among the most persistent obstacles in the field are unfavorable meteorological conditions, such as heavy

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[8] Sulthon Fathoni, "Problematika Tempat Rukyatul Hilal Di Kalimantan Timur," *SANGAJI : Jurnal Pemikiran Syariah Dan Hukum* 8, no. 2 (2024): 327–41, https://doi.org/10.52266/sangaji.v8i2.3455.

[9] Ridhokimura Soderi and Ahmad Izuddin, "Kajian Faktor Psikologi Yang Berpotensi Mempengaruhi Keberhasilan Rukyat," *Juris: Jurnal Ilmiah Syariah* 19, no. 1 (2020): 59–72, https://doi.org/10.31958/juris.v19i1.1930.

[10] Novi Arisafitri et al., "Territory, Hilāl, and Sovereignty: Revisiting Indonesia's Maṭla' under MABIMS' New Criteria," *Al-Hilal: Journal of Islamic Astronomy* 7, no. 1 (2025): 19–36, https://doi.org/10.21580/al-hilal.2025.7.1.25278.

[11] Abdul Mufid and Thomas Djamaluddin, "The Implementation of New Minister of Religion of Brunei, Indonesia, Malaysia, and Singapore Criteria towards the Hijri Calendar Unification," *HTS Teologiese Studies / Theological Studies* 79, no. 1 (2023): 8, https://doi.org/10.4102/HTS.V79I1.8774.

clouds, haze, or rain, which obscure the western horizon and prevent visibility of the crescent. Additionally, astronomical factors such as the *hilāl's* low altitude, faint brightness, and proximity to the twilight glow (*syafaq*) make detection extremely challenging, even with the aid of telescopes or optical devices.

Beyond astronomical constraints, *ru'yah al-hilāl* is also shaped by a combination of technical, human, and environmental considerations. The selection of an observation site is particularly crucial, as ideal locations require an unobstructed view of the western horizon, minimal light pollution, and sufficient elevation. Sites near coastal regions or dense urban centers often experience higher cloud formation or atmospheric interference, reducing the chances of a successful observation. Moreover, the psychological disposition of observers can influence the objectivity of visual interpretation. A strong expectation or emotional anticipation to sight the crescent may cause individuals to misinterpret atmospheric phenomena. In some regions, limitations in modern observational technology, including inadequate telescopic resolution or the lack of digital imaging systems, further diminish the precision and credibility of *ru'yah* results. These factors collectively underscore the need for both rigorous technical standards and continuous human resource development in the practice of lunar observation.

The complexity of the issue is compounded by methodological divergences in determining the start of the month across Islamic authorities. Some groups uphold *ru'yah bi al-fi'li* (direct, physical observation) as the only legitimate approach, while others favor *ḥisāb* calculations grounded in astronomical certainty. The MABIMS visibility criteria, which require the Moon to reach a minimum altitude of 3° with an elongation of at least 6.4°, serve as a regional standard in Southeast Asia;[12] yet, differences in the application or interpretation of these criteria often lead to inconsistent outcomes. Institutional perspectives further complicate the matter: for instance, Nahdlatul Ulama (NU) emphasizes *ru'yah* as the theological basis for certainty (*yaqīn*), whereas Muhammadiyah adopts *ḥisāb* with the *wujūd al-hilāl* criterion,[13] leading to frequent discrepancies in determining the beginning of Ramadan and Eid dates.[14] These methodological variations are not merely academic; they have tangible implications for social cohesion and religious uniformity within Muslim societies.

From a broader socio-political standpoint, differences in authority, interpretation, and procedural decision-making further intensify the fragmentation of lunar calendar determinations. Divergent rulings among national religious councils, government institutions, and independent organizations, both domestically and internationally, often result in Muslims observing major religious events on different days. This lack of synchronization may generate confusion, reduce communal unity, and occasionally spark theological debate within the public sphere. Consequently, the challenge of determining the Hijri month is not limited to technical or astronomical considerations alone, but extends to juridical legitimacy, institutional coordination, and public trust.

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[12] Mohd Saiful Anwar Mohd Nawawi et al., "Hijri Month Determination in Southeast Asia: An Illustration Between Religion, Science, and Cultural Background," *Heliyon* 10, no. 20 (2024), https://doi.org/10.1016/j.heliyon.2024.e38668.

[13] Maskufa Maskufa et al., "Implementation of the New MABIMS Crescent Visibility Criteria: Efforts to Unite the Hijriyah Calendar in the Southeast Asian Region," *AHKAM : Jurnal Ilmu Syariah* 22, no. 1 (2022): 209–36, https://doi.org/10.15408/ajis.v22i1.22275; Maskufa Maskufa, "Hisab Wujud al-Hilal sebagai Politik Identitas Muhammadiyah dalam Diskursus Hisab Rukyat di Indonesia," *Indo-Islamica Journal* 6, no. 2 (2016): 183–202.

[14] Arisafitri et al., "Territory, Hilāl, and Sovereignty: Revisiting Indonesia's Maṭla' under MABIMS' New Criteria."

Addressing these challenges requires a holistic framework that bridges the disciplines of astronomy, Islamic jurisprudence (*fiqh*), and governance, supported by the adoption of technological innovations that enhance both accuracy and transparency.

In this context, it becomes imperative to strengthen collaborative coordination among religious authorities, astronomical institutions, and government agencies. The formulation of shared standards and unified criteria, through mechanisms such as the *itsbāt* (confirmation session) in Indonesia or regional cooperation under MABIMS, serves as a critical step toward harmonization.[15] Such efforts aim to minimize discrepancies, enhance institutional credibility, and provide Muslims with greater clarity and certainty in fulfilling their religious obligations. Ultimately, the future of *ru'yah al-hilāl* lies in the integration of empirical astronomy, modern technology, and the ethical principles of *fiqh*, ensuring that the determination of the Hijri month remains both scientifically verifiable and spiritually authoritative.

3. Integrating Artificial Intelligence in *Ru'yah al-Hilāl*: Toward an Objective and Technological Framework for Hijri Month Determination

The methodological and observational challenges surrounding *ru'yah al-hilāl*, ranging from atmospheric limitations to psychological bias, underscore the urgent need for innovative and technology-assisted approaches in lunar sighting practices. In recent years, the intersection between Islamic astronomy and modern computational science has opened new avenues for enhancing the precision, transparency, and credibility of the Hijri calendar determination. Among these innovations, Artificial Intelligence (AI) has emerged as a particularly promising tool, offering the potential to complement traditional *ru'yah* methods with data-driven verification and standardized analysis.

Since 2019, AI has become one of the most transformative and disruptive technologies of the digital era. As an advanced computational framework, AI operates through algorithms capable of performing complex reasoning, generating responses, and executing tasks with remarkable speed and precision. Its applications now extend across a wide spectrum of sectors, including healthcare, finance, commerce, education, transportation, and entertainment, each deriving substantial benefits from AI-driven optimization. The adoption of AI is largely driven by its capacity to enhance efficiency, minimize human error, and accelerate decision-making. Given its continued evolution, AI is widely recognized as a central pillar in the global digital transformation shaping both industry and academia.[16]

The integration of AI into the *ru'yah al-hilāl* (crescent moon sighting) process represents a transformative step forward in the modernization of Islamic astronomy. Traditional *ru'yah* practices have long relied on human observation, which is susceptible to perceptual limitations, environmental factors, and interpretive subjectivity. Through the implementation of AI-based

[15] Ismail Ismail et al., "Ulama and Islamic Astronomy in Contemporary Indonesia: T.M. Ali Muda's Concept on Matlak Hilal," *Journal of Indonesian Ulama* 3, no. 1 (2025), https://doi.org/10.30821/JIU.V3I1.596.

[16] Adib Bin Rashid and Md Ashfakul Karim Kausik, "AI Revolutionizing Industries Worldwide: A Comprehensive Overview of Its Diverse Applications," *Hybrid Advances* 7 (December 2024): 100277, https://doi.org/10.1016/j.hybadv.2024.100277; Chinimilli Venkata Rama Padmaja et al., "The Rise of Artificial Intelligence: A Concise Review," *IAES International Journal of Artificial Intelligence (IJ-AI)* 13, no. 2 (2024): 2226–35, https://doi.org/DOI:%252010.11591/ijai.v13.i2.pp2226-2235.

systems, the identification of the *hilāl* can now be conducted objectively, consistently, and with minimal cognitive bias.[17] The system introduced in this study utilizes Google's Teachable Machine, a machine-learning platform that enables non-specialists to design and train AI models efficiently. The model is trained using a labeled dataset that distinguishes *hilāl* images from non-*hilāl* ones, allowing the algorithm to classify new observations with a high degree of accuracy. After training, the AI model is integrated into a web-based application developed with HTML, CSS, and Python, and hosted on GitHub to ensure open accessibility.[18] This integration not only enhances usability but also enables researchers, educators, and religious institutions to employ the system without requiring technical installation or proprietary software.

The adoption of AI within the *ru'yah* framework further promotes democratization and transparency in the process of lunar visibility verification. In the future, even individuals without formal expertise will be able to conduct independent *hilāl* validations using only a smartphone and an internet connection. This innovation significantly broadens public participation, transforming *ru'yah* from a specialized practice performed by astronomers or authorized observers into an inclusive and participatory process supported by digital infrastructure. Nevertheless, it is essential to acknowledge that AI, despite its sophistication, is not an infallible instrument. Misclassification errors or anomalies may still occur due to limitations in training data or environmental conditions captured in images. Therefore, the outputs generated by AI must be verified through expert review and institutional validation before being accepted as conclusive evidence.

In this context, AI should be understood not as a replacement for human observers but as a decision-support tool that enhances accuracy, consistency, and accountability in the *ru'yah al-hilāl* process. By bridging computational intelligence and religious epistemology, the AI-based model strengthens both the scientific and theological dimensions of lunar observation. This synthesis of faith and technology marks a critical advancement in the pursuit of a more standardized, transparent, and globally harmonized Hijri calendar, one that respects the principles of Islamic law while embracing the capabilities of modern science.

4. AI-Based Validation of *Hilāl* Visibility: A Case Study of the Aceh Jaya Observation for Zulhijjah 1446 H

On May 27, 2025, during the national *ru'yah al-hilāl* (crescent sighting) to determine the beginning of Zulhijjah 1446 AH, the Aceh region became the primary focus of observation. This prominence was due to the fact that Aceh was the only area in Indonesia meeting the *imkān al-ru'yah* criteria, suggesting that the crescent moon was potentially visible. A unique situation unfolded in Aceh Jaya Regency, particularly at Kuala Doe Beach, Gampong Lhok Geulumpang, Setia Bakti District, where two *itsbāt* (confirmation) sessions were convened on the same day. During the first session, the observation team reported that the *hilāl* was not visible, as recorded in Court Decision

[17] Samia Loucif et al., "Toward a Globally Lunar Calendar: A Machine Learning-Driven Approach for Crescent Moon Visibility Prediction," *Journal of Big Data* 11, no. 1 (2024): 114, https://doi.org/10.1186/s40537-024-00979-6; Rofiuddin and Ardliansyah, "The Utilization of Artificial Intelligence in Determining the Beginning of Islamic Calendar in Indonesia"; Muh Rasywan Syarif et al., "A Semantic Literature Review on Crescent Visibility: Trends, Models, and Implications for the Islamic Calendar," *Al-Hilal: Journal of Islamic Astronomy* 7, no. 1 (2024): 67–88, https://doi.org/10.21580/al-hilal.2025.7.1.26099.

[18] Fabiano Pereira de Oliveira et al., *TMIC: App Inventor Extension for the Deployment of Image Classification Models Exported from Teachable Machine*, 12, no. Ml (2022).

No. 71/Pdt.P/2025/MS.Cag. However, later that evening, at approximately 19:30 GMT+7, a second session was held upon the submission of photographic evidence and witness testimony. The Aceh Jaya Syar'iyah Court, after reviewing the new evidence, concluded that the *hilāl* had indeed been sighted, as documented in Court Decision No. 72/Pdt.P/2025/MS.Cag. This ruling subsequently formed the basis for the Decree of the Minister of Religious Affairs of the Republic of Indonesia (KMA) No. 580 of 2025, officially declaring May 28, 2025, as 1 Zulhijjah 1446 AH, with the *ru'yah* (visual sighting) status affirmed.[19]

In light of the controversy surrounding the Aceh Jaya observation, this study aims to validate the claimed visibility of the *hilāl* using a web-based artificial intelligence (AI) system developed on Google's Teachable Machine platform. The AI model had previously been trained using a labeled dataset comprising *hilāl* and non-*hilāl* images, enabling it to perform binary classification with measurable accuracy. For this case study, two photographic samples from the Aceh Jaya *ru'yah* session, captured at Kuala Doe Beach, were analyzed using the AI system to assess whether the images genuinely depicted the *hilāl*. The objective was to compare the AI-generated classification outcomes with the official field observations, thereby evaluating the accuracy, objectivity, and practical utility of AI in supporting lunar visibility verification.

The AI validation process was conducted through a dedicated website accessible via the link https://ravik-25.github.io/website-analisis-citra-hilāl/. The system integrates the trained Teachable Machine model into a browser-based interface developed using HTML, CSS, and Python, and hosted on GitHub for open accessibility. Users can upload photographic evidence directly into the interface, where the model automatically analyzes the image and outputs a probabilistic prediction indicating whether the image belongs to the *hilāl* or non-*hilāl* category. This client-side processing eliminates the need for specialized installations or advanced computational expertise, allowing researchers, educators, and authorized institutions to independently conduct preliminary verifications. The platform thereby serves as a decision-support tool, enhancing transparency and accessibility in the *ru'yah* process through AI-assisted image recognition.

The following figures present sample photographs used for testing the *hilāl* image classification. These images were obtained directly from the *ru'yah al-hilāl* Team of the Ministry of Religious Affairs, Aceh Province, who accompanied the national observation team during the *ru'yah al-hilāl* activities in Aceh Jaya. Figures 1 constitutes the official visual documentation submitted by the Aceh Jaya *ru'yah* team and were identified as representations of the *hilāl* for 1 Zulhijjah 1446 H.

[19] Mahkamah Syar'iyah Aceh (ms-aceh.go.id), "Unik, Hilal terlihat setelah 2 kali sidang dengan 2 permohonan."

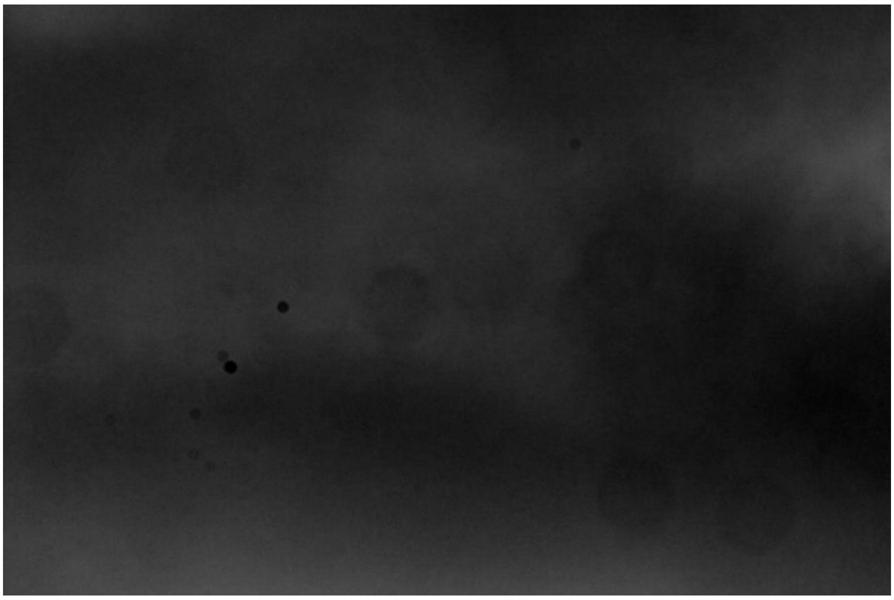

Figure 1. Photographs suspected to depict the *hilāl* image

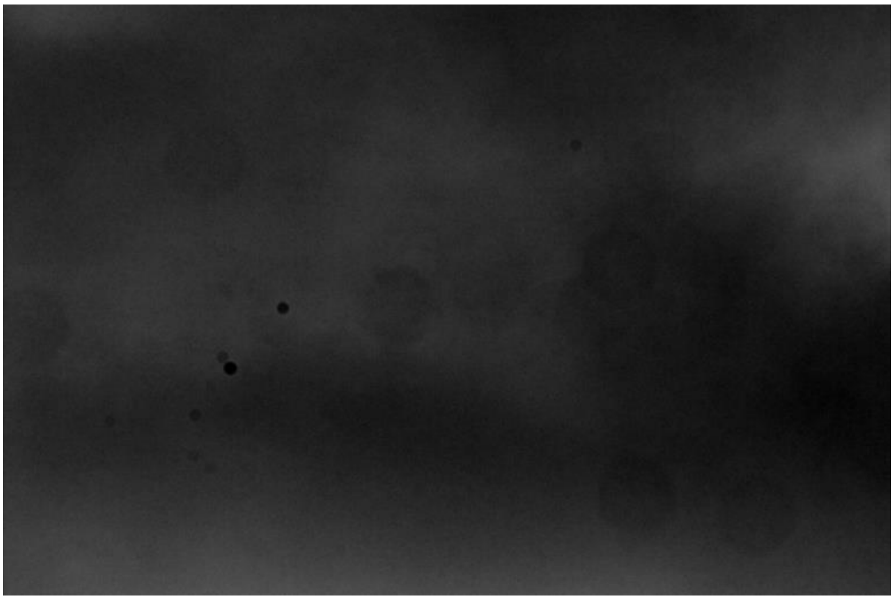

Figure 2. Photograph suspected to depict the *hilāl* image

Given the uncertainty surrounding the authenticity of the *hilāl* photograph, this study employed Google's Teachable Machine, a browser-based platform for developing lightweight artificial intelligence (AI) models. Built on the TensorFlow.js framework, the platform enables users to train image classification models without advanced programming or specialized hardware. A custom AI model was trained using labeled datasets of *hilāl* and non-*hilāl* images to verify whether the photographed object truly represented the crescent moon.[20] This approach allowed for a rapid

[20] Midhun P Mathew and Therese Yamuna Mahesh, "Object Detection Based on Teachable Machine," *Journal of VLSI Design and Signal Processing* 7, no. 2 (2021), https://doi.org/10.46610/jovdsp.2021.v07i02.003.

and accessible analytical process, providing an objective validation of the doubtful *hilāl* imagery while minimizing human interpretive bias.[21]

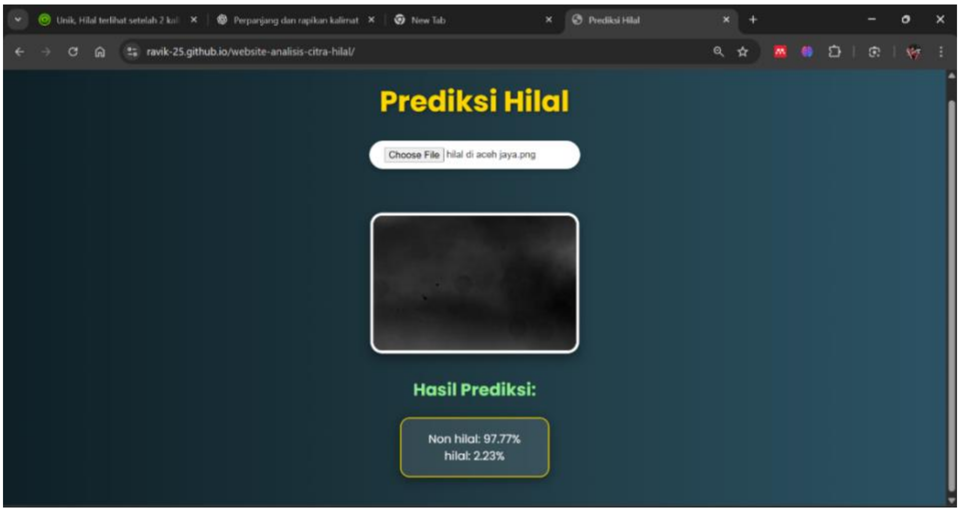

Figure 3. *Hilāl* verification result with AI

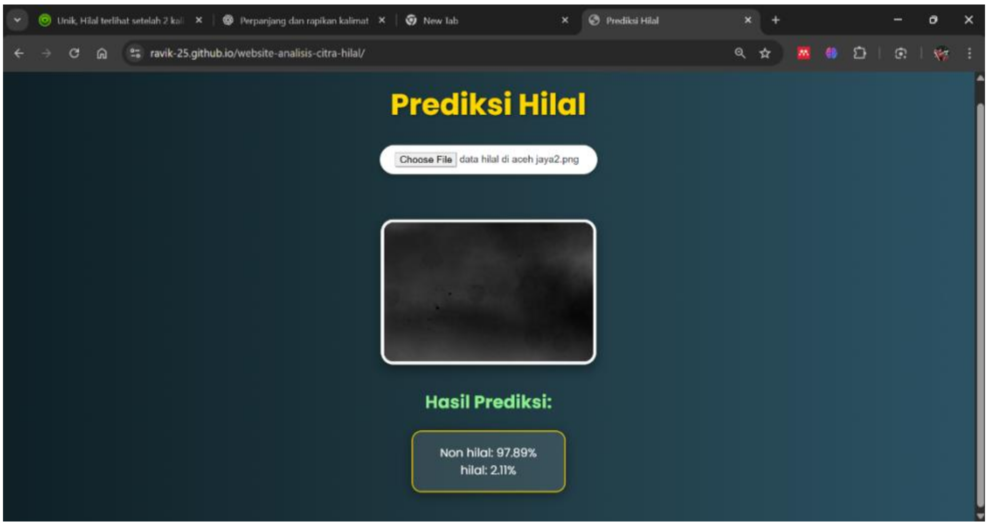

Figure 4. *Hilāl* verification results with AI

The AI verification results are presented in Figures 3 and 4. In Figure 3, the system classified the image as non-*hilāl* with a confidence level of 97.77%, while the probability of it being *hilāl* was only 2.23%. Similarly, the second image (Figure 4) was classified as non-*hilāl* with a confidence level of 97.89%, leaving only 2.11% probability for the *hilāl* category. These results indicate that both images most likely depict non-lunar visual phenomena, possibly caused by camera noise, atmospheric scattering, or light reflection, rather than an actual crescent moon. The AI model's

[21] Emmanuel Agung Nugroho et al., "Image Classification System Design for Yarn Inspection Process Using Teachable Machine and Raspberry Pi," *ICSMech 2024 - 1st International Conference on Smart Mechatronics: Transformative Innovations in Smart Mechatronics: Bridging AI, Robotics, and IoT for a Sustainable Future*, no. November 2024 (2024): 19–24, https://doi.org/10.1109/ICSMech62936.2024.10812271.

consistent classification across both samples demonstrates its high reliability and repeatability in image-based *hilāl* assessment.

The findings from this validation study affirm that the two photographic samples from the Aceh Jaya *ru'yah al-hilāl* observation did not contain verifiable evidence of the crescent moon. The AI model consistently classified both images as non-*hilāl* with confidence levels exceeding 97%, supporting the conclusion that the reported sightings were likely misinterpretations. This result not only strengthens the argument for integrating AI in *ru'yah* verification but also highlights its potential as a supplementary, objective, and replicable tool for both scientific and religious authorities. By applying machine learning to the field of Islamic astronomy, this study underscores the value of technological collaboration in improving the credibility, transparency, and methodological standardization of lunar visibility determinations.

The AI-based validation reinforces the longstanding challenge within *ru'yah al-hilāl* practices, the tension between human perception and scientific verification. The consistent classification of the Aceh Jaya photographs as non-*hilāl* with confidence levels above 97 percent illustrates that visual observations, even when accompanied by photographic evidence, remain vulnerable to perceptual bias and environmental distortion. From a jurisprudential standpoint, this finding aligns with the principle of *taḥarrī al-yaqīn* (pursuit of certainty), which obliges decision-makers to prioritize clear and verifiable evidence in matters of religious determination. It also affirms that while *ru'yah bi al-fi'li* (direct sighting) holds theological significance, it must be interpreted in harmony with the principles of *'ilm al-yaqīn* (scientific certainty). Thus, the integration of AI-assisted analysis provides a methodological bridge between empirical astronomy and Islamic legal reasoning, ensuring that determinations of the Hijri month rest on both credible observation and rational verification.

Building upon these insights, future *ru'yah al-hilāl* practices should incorporate AI-assisted image verification as a standard complementary procedure to manual observation. Religious authorities and astronomical institutions can collaborate to develop a national digital verification platform using open-source AI tools such as Teachable Machine or others, enabling rapid analysis of field data during *itsbāt* sessions. This system should operate under the supervision of certified astronomers and juridical experts (*fuqahā'*) to maintain both scientific accuracy and religious legitimacy. Additionally, training programs for observers should include basic instruction in image documentation and digital validation to reduce misinterpretation. Through institutional adoption of these innovations, Indonesia can strengthen the credibility, consistency, and transparency of *ru'yah al-hilāl* determinations, setting a model for integrating emerging technologies into contemporary Islamic astronomical governance.

D. Conclusion

The case of *ru'yah hilāl* at Kuala Doe Beach, Aceh Jaya, for 1 Zulhijjah 1446 AH represents a significant and unusual event in Indonesia's lunar observation history. Two *itsbāt* sessions were held on the same day, with the first concluding that the *hilāl* was not visible, while the second, prompted by photographic claims and witness testimony, declared that it had been sighted. This procedural anomaly highlights the inherent challenges of relying solely on human perception in determining the beginning of the Hijri month, particularly under atmospheric and psychological conditions that may compromise objectivity. The incident underscores the urgent need for empirical verification mechanisms that can complement the *ru'yah bi al-fi'li* (direct sighting) tradition, ensuring that decisions of religious and national significance are grounded in both observation and evidence-based validation.

Using an AI model developed through Google's Teachable Machine platform, the photographic documentation from the Aceh Jaya observation was re-evaluated. The system consistently classified the images as non-*hilāl* with a confidence level exceeding 97%, indicating that the observed object was unlikely to represent the crescent moon. This analysis provides a strong empirical basis to question the validity of the claimed sighting while demonstrating the practical potential of AI as a decision-support tool in *ru'yah hilāl* verification. The findings emphasize that AI-based image analysis can enhance the transparency, accuracy, and reproducibility of lunar visibility assessments, bridging the gap between traditional Islamic astronomy and modern computational science.

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