History of Location Objectives (Hilal Tracker): Development of Astronomical Observations from 2015-Present

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Abstract

This study examined the development of Hilal Tracker as a system for determining the location of *hilal* observations that has been developed since 2015 until now. This system emerged from the need for an accurate, efficient, and documented way to find the best place to see the *Hilal*, which is an important factor in determining the beginning of the month in the Hijri calendar. This article explains the history of the development of *hilal* Tracker technology and methods, including integrating astronomical data, using satellite imagery, algorithms for predicting *hilal* visibility, and cooperation with various local and international institutions. With a historical qualitative approach and chronological documentation, this paper examined the changes in innovation from the early phase to the modern stage. The findings showed that Hilal Tracker has improved the accuracy of *rukyat* location selection, strengthened the global *hilal* visibility database, and supported the alignment of *hisab* and *rukyat* methodologies in some Islamic countries. In addition, this system functions as a link between classical Islamic astronomy and modern technology through an open approach and academic collaboration. Therefore, Hilal Tracker is not just a technical device, but also a means of education and diplomacy in creating a unified Hijri calendar worldwide with an observational approach. This study recommends further development of local weather forecasting aspects and artificial intelligence to improve location efficiency in the future.

Keywords: Hilal Tracker, Islamic Astronomy, Calendar

Introduction

Astronomy, as the study of celestial objects and natural phenomena, has been an essential part of humankind's efforts to understand its place in the universe. Since ancient times, humans have diligently observed the movements of celestial objects and developed tools to support these observations. One crucial yet often overlooked element in the history of astronomy is the role of "goal locations," which refer to specific geographic points used for astronomical observations.[1] These

[1] Arwin Juli Rakhmadi Butar-Butar. Pengantar Ilmu Falak Teori, Praktek, Dan Fikih. Depok: Rajawali Press, 2018.

locations often play a significant role in influencing observations and the resulting theories.[2] Astronomy is one of the oldest sciences that has emerged since the beginning of human civilization. Humans have long observed the movements of the sun, moon, stars, and planets to understand the cycles of time and natural phenomena. Although ancient astronomical observations were hampered by technological limitations, the location and local sky conditions greatly influenced the results of observations.[3] Strategic locations, especially high and away from natural and artificial disturbances, are preferred for more accurate observations. In ancient Mesopotamia, for example, stargazing was done from towers or ziggurats built in the open to minimize atmospheric disturbances.

The history of astronomical instruments began with observing stars with the naked eye, which prompted humans to look for ways to improve the accuracy of observations. The first tools in ancient astronomy included simple devices for measuring the positions of celestial objects, such as poles or towers used by the Mesopotamians to monitor the movements of stars and planets. At that time, the choice of goal location was based on the practical need to make simple but effective observations, relying on a higher geographical position or being more open to disturbances such as fog or rain.

Astronomy is not just a branch of science that focuses on celestial phenomena; it also significantly impacts our daily lives. One important aspect of astronomical observation in various cultures is determining the beginning of the new month. This process is closely related to the calculation of the Islamic calendar.[4] The determination of the new month is usually done by observing the first crescent moon, which is the sign of the beginning of the new month in the Islamic lunar calendar. This process is crucial for determining the times of worship, including the holy month of Ramadan and Eid al-Fitr.[5]

The development of knowledge and technology in astronomy, especially those related to crescent moon observations and determining the beginning of the Hijri month, has shown significant progress in recent years. In this case, the accuracy of data regarding the location, time, and visibility parameters of the crescent moon is a key factor in ensuring the validity of an observation. With the increasing need for accurate, fast, and scientifically verifiable information, various observation support systems have emerged, combining computer-based astronomy, digital geospatial, and user-friendly interfaces.[6] The crescent moon tracker emerged as a solution to overcome the challenges in crescent moon observations. So far faced various obstacles, from the accuracy of observation locations, lack of local astronomical data, to differences in crescent moon determination criteria between institutions and countries.

This system is not only designed as a tool for visualizing crescent moon data, but also as a collaborative platform that allows users to contribute to improving the location database, entering results, and verifying astronomical parameters directly. One of the most important features in this system is location objectives, which is a system for determining and managing observation locations based on spatial data and certain scientific criteria.[7]

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[2] Putri, J. "Biografi Filsuf Abad Renaisans (Copernicus) Pemikirannya dalam Dunia Pendidikan Saat Ini dan Relevansi." 05, no. 1 (2024): 39–44.

[3] Nur Ahmad Irfai. "Astronomi Dalam Penafsiran Ibnu ʼĀsyūr Dalam Kitab Tafsir Al-Taḥrīr Wa Al-Tanwīr." Tesis, UIN Raden Intan Lampung, 2023.

[4] Muhammad Qorib, Zailani, Radiman, Amrizal, and Arwin Juli Rakhmadi Butar-Butar. "Peran Dan Kontribusi Oif Umsu Dalam Pengenalan Ilmu Falak Di Sumatera Utara." *Jurnal Pendidikan Islam* 10, no. 2 (2019): 133–41.

[5] Rahman, Arif Fahtur. "UJI AKURASI QIBLAT TRACKER RHI DALAM MENENTUKAN ARAH KIBLAT MENGGUNAKAN AZIMUT BINTANG." Tesis, UIN Walisongo Semarang, 2019.

[6] Putri, J., & Ferianto, F. Kemajuan Peradaban Islam Di Era Society 5.0. Wahana Karya Ilmiah Pendidikan 7, no. 1 (2023): 42–54.

[7] Meilinda Dwi Lestari. "PENANAMAN KARAKTER RELIGIUS, DISIPLIN DAN TANGGUNG JAWAB PESERTA DIDIK MELALUI EKSTRAKULIKULER TAPAK SUCI PUTERA MUHAMMADIYAH DI SMA MUHAMMADIYAH 1 PONOROGO." Skripsi Sarjana, Institut Agama Islam Negeri Ponorogo, 2018.

Among the main features of this system, location objectives play an important role in determining the coordinates of observation sites that meet technical and scientific requirements, as well as considering practical aspects such as easy access, visibility, and astronomical validity. Over time, this system has undergone various revisions, developments, and improvements in calculation accuracy and user interface integration. However, during its development, this feature has undergone improvements in technical aspects such as coordinate accuracy, horizon height calculation, crescent visibility, and social aspects by involving users in the location filtering and validation process.[81] These changes show that the location objectives system is not a final product but a process that adapts to changing observation needs and technological advances.

The background to the emergence of the crescent tracker cannot be separated from the needs of the Islamic astronomy community, both among academics, Islamic organizations, *rukyat* institutions, and independent observers, for a tool that can connect astronomical theory with observation practices in the field. The location objectives system, which previously only offered static observation points, has now evolved into a dynamic system considering various factors, such as *imkanur rukyah* criteria, crescent parameters, horizon elevation, and even visibility simulations based on real time and user location. This change has a major impact on observation practices from a technical and organizational perspective. With the increasing needs of users and the ever-growing capabilities of digital technology, the *hilal* tracker is slowly expanding the scope and capabilities of its system. Not limited to key locations in Indonesia, this system is now widely used by astronomical communities from various countries, especially in global discussion forums related to the Islamic calendar. The role of the location objectives system is not merely as a technical tool, but also as a collaborative medium that supports efforts to standardize *hilal* observation methods more scientifically and transparently.[9]

However, the development of this system is not free from various challenges. Changes in location algorithms, variations in *hisab* and *rukyat* methods in various organizations, and user reactions to system updates are dynamic elements that should be studied from a historical and qualitative perspective. In addition, records of the system revision and evaluation process over time are still considered minimal, so it is important to conduct research that systematically traces the history and dynamics of the development of location objectives in *hilal* trackers from the beginning to the present.[10]

This study aims to reconstruct the history of the development of location objectives in crescent trackers from 2015 to the present, and to evaluate its impact on the effectiveness of Islamic astronomical observations, especially in *rukyat Hilal*. In addition, this study also aims to identify factors that drive system changes, both from the perspective of user needs, scientific considerations, and related social and religious dynamics.[11] By understanding this history, it is hoped that a more comprehensive insight will emerge into how a digital system can develop flexibly to meet the demands of dynamic Islamic astronomical practices.

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[8] M. Aufa Anis Ar Rofif. Optimalisasi Instrumen Optik dan Pengaruhnya pada Kalibrasi Proses "Setting Circle" Teleskop Skywatcher 90/910 EQ2 Untuk Keperluan Rukyat Hilal. Skripsi Sarjana, UIN Walisongo Semarang, 2022.

[9] A. HUSEIN, "Perancangan Aplikasi Android Mobile Gawang Lokasi Untuk Rukyat Hilal Berbasis Sensor Gyroscope Tesis." UIN Walisongo Semarang, 2021.

[10] Muhammad Basithussyarop. "Problematika Astrofotografi Dalam Rukyatul Hilal." *Elfalaky* 6, no. 1 (2022): 111–136.

[11] Nurhartanto, A. "Kajian Komprehensif Metode Hisab dalam Penentuan Awal Bulan Syawal dan Ramadhan." Journal *Pedagogy* 8, no. 2 (2015): 2–5.

Modern Hilal Trackers utilize advanced technologies to facilitate automatic and precise crescent observations.[12] Some of the technologies used in the Hilal Tracker include:[13]

1. GPS System and Optical Sensor: This tool combines GPS technology to track the observer's position and an optical sensor that can detect moonlight with high sensitivity.
2. Astronomy Software: Astronomy algorithms and software are used to predict the time and position of the crescent by calculating based on the position of the moon, sun, and geographic location of the observer.
3. Light Pollution Filtering: To maintain the quality of observations, the Hilal Tracker is equipped with light pollution filtering technology, allowing observations to be made even if there is interference from light from the surrounding environment.

This study is essential considering that the literature on developing digital-based astronomical systems in Indonesia is still very limited, especially those highlighting technical and location aspects in the context of *rukyat*. This study is expected to contribute to academic literature and be a historical document that adds insight into the development of technology-based Islamic science in the modern era. Furthermore, this study can be a foundation for developing similar systems with a more collaborative, contextual, and responsive approach to user needs.

This study will use a qualitative and historical approach to explore development documents, interview developers and system users, and observe application usage over time. From there, it will be explained how technical changes, feature innovations, and user responses influence each other in location goal evolution. This analysis will be directed to comprehensively understand this transformation in *rukyat hilal* practices and Islamic astronomical observations. This study will provide useful information for developers of hilal tracking systems in evaluating and designing further developments. In addition, users from *rukyat* practitioners, academics, and religious authority institutions can use this study's results to determine observation locations that are more accurate and relevant to local and regional needs. This research can also be a discussion material in scientific and religious forums that discuss harmonizing the global Hijri calendar.

Ultimately, by using a historical and qualitative approach, this study attempts to reconstruct the development of the location objective system from 2015 to the present, explore the factors that drive each system update, and assess its impact on the quality of Islamic astronomical observations carried out by various parties, ranging from individual observers, Islamic mass organizations, to official state institutions.

Research Method

This study used a qualitative approach that is descriptive and historical to explore the development of the Location Objectives system on the crescent moon tracking platform from 2015 to the present. The qualitative method was chosen because the main purpose of this study is not to calculate variables numerically, but rather to deeply understand the historical context, dynamics of development, and important stories that underlie the emergence and development of this system in Islamic astronomical observations. The historical approach is used to reconstruct the development of the system in the order of time and innovation. This study is descriptive, meaning that it systematically describes the various factors that influence the evolution of the crescent moon tracking system over

[12] Rausi, F. Hisab Al-Karawi : Penentuan Awal Pasah dan Tellasan di Pondok Pesantren (Tinjauan Astronomi dan Respons Masyarakat). (2020): 1–150.

[13] Ahmad Fauzan, Annisa Khalawatul Zakiah, Annisa Mumtaza, Dian Rizka Hakiki, Fadiyah Septi Alfiyahni, Ihsanul Amin. "Penetapan Awal Bulan Hijriyah Dan Integrasinya Dengan Perhitungan Matematika." *Jurnal Religion: Jurnal Agama, Sosial, Dan Budaya P-ISSN : 2962-66560 , E-ISSN : 2963-7139*. 32 no. 1 (2023): 107–130.

time. The researcher does not attempt to produce generalizations or test hypotheses, but rather documents, interprets, and gives meaning to the development of the system in terms of technology, methodology, and its contribution to the current practice of *rukyat Hilal* and astronomical observations. With this technique, the researcher recorded how the system is implemented, how users obtained and interpreted location data, and its influence on determining the time and place of crescent moon observation. After the data was collected from various references, the next step was to conduct data analysis with a thematic approach. The analysis began with data reduction, selecting and sorting relevant and meaningful information from all existing articles.

Furthermore, the data was grouped based on main themes: stages of system development, adjustment of astronomical locations and parameters, collaboration within the community, impact on *rukyat* results, and challenges and prospects for future development. Each theme was analyzed in more depth to understand the interrelationships between elements and their impact on the effectiveness of the crescent moon tracking system in supporting Islamic astronomical observations. To ensure the validity and credibility of the data, this study used source triangulation techniques, namely analyzing data from various sources such as documents, magazines, journals, and the internet and comparing their consistency. Member checks were also applied by confirming with the source person regarding the researcher's interpretation to ensure that the source person intended the meaning captured. Interpretative validity is also maintained through re-reading and reflective thinking by the researcher regarding the social and scientific context of the crescent moon tracking system. By using this historical descriptive qualitative approach, it is hoped that this study will be able to provide a comprehensive and in-depth understanding of the dynamics of the development of Location Objectives in crescent moon tracking, including its contribution to strengthening the methodology of astronomical observations based on precision location data in the current *rukyat hilal* practice. This approach also emphasizes that understanding Islamic observation technology is not only technical, but also rich in social, historical, and cultural dimensions that need to be studied through reflective and contextual qualitative methods.

Discussion

The development of the crescent tracking system that began in 2015 until now has shown significant changes in Islamic astronomical observations, especially in determining the beginning of the Hijri month based on the location and visibility of the crescent. The key results indicated that the Crescent Tracker has undergone various technological, methodology, and community involvement changes since its creation.[14] Climatological data and the processing of crescent visibility algorithms have shifted the traditional method to a more objective, scientific, and standardized system.

In its early years, this system focused on collecting *rukyat* location data commonly used by observers in Indonesia. Research showed that over 250 observation points are registered from several provinces, but not all have been recorded digitally and scientifically. The initial initiative of the Crescent Tracker was to record these points regularly through a database that can be accessed and updated.[15] This update includes geographic coordinates, altitude, sky conditions, ease of access, and history of successful crescent observations. The discussion also showed that since 2017, *hilal* trackers have begun to adopt astronomical criteria for hilal visibility, such as Danjon Limit, Odeh, Yallop, and LAPAN criteria. It indicates a shift from simply recording locations to providing more science-based visibility

[14] Rahmatiah HL. "Dinamika Penentuan Bulan Ramadhan Dan Syawal Pada Masyarakat Eksklusif Di Kabupaten Gowa." *Elfalaky* 3, no. 1 (2019).
[15] Rika Widianita, D. "Efek Polusi Cahaya Dalam Pengamatan Hilal di Indonesia (Analisis Kriteria Kecerlangan Langit Menurut Nur Nafhatun Md Shariff)." *In AT-TAWASSUTH: Jurnal Ekonomi Islam*, Vol. VIII (Issue I), (2023).

predictions. Using these predictions is beneficial for Indonesia's *rukyat* community and as a reference source for other countries such as Malaysia and Brunei Darussalam.

Documentation data in 2018 shows that more than 70% of the locations registered in the Hilal Tracker database have been actively used for observation. In addition, 35% of them show consistency in hilal visibility in certain months. It is the basis for classifying strategic, ideal, and less ideal locations, which several national and regional astronomy institutions then recommend. Since 2019, the system has also expanded its services by providing a digital field report feature that allows observers to immediately report observation results with reporting standards based on astronomical parameters such as crescent height, elongation, moon age, crescent sun azimuth, and sky conditions. The observation results recorded through this system show a significant improvement in the quality of reports compared to previous manual reports.[16] Several field reports have been re-checked with data from satellites and professional observatories.

Another important finding is the impact of this system on forming a new pattern in Islamic astronomy training. Observations of training activities in various Islamic boarding schools and universities show that the crescent tracker is a teaching tool to introduce practical aspects of astronomical science. Training data even shows that participants are increasingly skilled in determining the direction of the Qibla, measuring the height of the crescent, and mapping ideal locations using interactive maps provided by this system.[17]

It is important to note that the crescent tracker has formed a new framework of knowledge that combines various disciplines: astronomy, information technology, geography, and religious studies. This system is an "epistemological bridge" between traditional astronomical and modern science in many regions. It can be seen from how *hilal* observers began to use technical terms such as "elongation," "age of the moon," or "hilal altitude" in their rukyat reports. This change in language usage reflects a shift in the culture of knowledge from intuition to measurement and quantification.

The involvement of educational institutions in developing this system is essential to note. Islamic universities, such as UIN, IAIN, and Muhammadiyah universities, use *hilal* trackers as part of their student or field observation practices. Some also create small studies based on data from this system as final assignments and theses. The *hilal* tracker is a tool and a reliable primary data source for scientific research.

The *hilal* tracker reflects a change in the digital era's way of looking at rukyat. It symbolizes technological developments and reflects the collective spirit of Muslims to combine science, community involvement, and religious traditions in a more open, inclusive, and scientifically based approach. The future of this system depends heavily on its ability to continue to adapt, innovate and maintain scientific integrity amidst global challenges.[18]

The acceptance of the *hilal* tracker by the Islamic astronomy community and astronomy observers in various regions has shown a very good response, as seen from the increase in the number of active users, observation reports, and participation in system development because the system meets the main needs of observers, such as location accuracy, easy access, and integration of astronomical data in one simple platform; astronomy communities in areas such as North Sumatra, Central Java, South Sulawesi, and parts of Malaysia have begun to include the *hilal* tracker in their rukyat practical training programs, showing that this system has succeeded in reaching both educational and application areas.

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[16] Rahmatiah HL. "Dinamika Penentuan Bulan Ramadhan Dan Syawal Pada Masyarakat Eksklusif Di Kabupaten Gowa." *Elfalaky* 3, no. 1 (2019).

[17] Jamaluddin, M. F. Urgensi dan Relevansi Kalender Hijriah Unifikatif; Perspektif Historis dan Problem Praktis. Ppmimesir.or.Id, 4, 1992.

[18] Gilang Ramadhan, M. Zuhri Abu Nawas, & Muhammad Tahmid Nur. "Pandangan Ulama Dan Pemerintah Indonesia Terhadap Penentuan Awal Bulan Kamariah: Eksplorasi Perspektif Maqashid Syariah." *Jurnal Yustisiabel* 8, no 1 (2024): 124–137.

In discussions about Islamic astronomy, this application is often proposed as the main tool in determining the best observation location, as a replacement for the old method that only relies on maps or direct experience; astronomy teachers, lecturers, and ustadz who teach the science of hisab have begun to introduce this application to students and university students as part of digital literacy in Islamic astronomy; its influence can be seen from the rukyat hilal report which includes the coordinates of the tracking results via the *hilal* tracker, along with information about elevation and local weather conditions; This is a significant improvement compared to previous reports that were more narrative and less standardized.[19]

From a social perspective, the use of the *hilal* tracker expands community involvement in *rukyat* activities; ordinary people can now participate in *hilal* observations without needing to have in depth knowledge of astronomy, because this system presents astronomical data in a way that is easier to understand and is displayed visually; in various trainings, participants showed high enthusiasm for using this application, especially because they could directly feel its benefits in determining prayer times more precisely; increased understanding of astronomy is also a positive impact of this system, where people are starting to become familiar with terms such as azimuth, elongation, and the angle of the moon's altitude.[20]

To understand the role of the *hilal* tracker in the ecosystem of astronomical observation applications, this study compares it with several similar systems such as Stellarium Mobile, SkySafari, and other Muslim applications such as Muslim Pro or Hijri Calendar; the main difference lies in the focus of its development, where hilal tracker is specifically designed for *hilal rukyat* and observation of celestial phenomena based on locations that have sharia relevance, not just for sky simulation.[21] Stellarium and Sky Safari have fairly advanced simulation features, but do not provide a database of empirically and practically verified field locations, and do not have a rukyat report feature; Muslim Pro and other *hijri* applications do have *hisab* data, but do not offer *rukyat* location maps or interactive features to determine observation locations; in this case, *hilal* tracker fills an important gap in the integration between practical stargazing observations and geospatial technology.

Another advantage lies in the community and collaboration aspects, which are not found in other applications; the hilal tracker system allows users to share locations, record observation results, and even start discussion forums about possible *rukyat* locations; this feature creates an organic database that continues to grow, according to field needs and experiences, making it a living system that grows naturally through community contributions.[22]

Although it has proven effective and gained wide acceptance, the *hilal* tracker still faces several serious challenges, including dependence on GPS data and signal stability issues in some areas; users in mountainous areas, border areas, or locations without signal often experience difficulties in accessing maps directly; Although offline features exist, not all information can be downloaded without a connection, especially related to weather data and estimated positions of celestial objects.

Another challenge is the lack of official approval from several state authorities for data reported through the crescent tracker; several institutions still require manual reports in conventional formats, so that reports in digital form are considered complementary, not the main one; this shows the need

[19] Muhammad Arsyad Alkadafi, Muhammad Akmal, Arditya Prayogi, Muhammad Akmal. ISLAM DAN KONTRIBUSINYA TERHADAP PERKEMBANGAN ILMU PENGETAHUAN : SUATU TELAH ISLAM AND ITS CONTRIBUTION TO THE DEVELOPMENT OF SCIENCE : A STUDY. November, (2024): 6325–6334.

[20] Zahroya, Isyvina Unai. "RESPONS PERUKYAT METODE TRADISIONAL DAN SAINS DALAM KEBERHASILAN RUKYAT AL-HILĀL AHMAD ASYHAR SHOFWAN." Tesis, UIN Walisongo Semarang, 2022.

[21] Muhamad Rezi. "Pemahaman Hadis-Hadis Rukyat Hilal dan Relasinya dengan Realita Isbât Ramadhan Di Indonesia." *Alhurriyah: Jurnal Hukum Islam* 1, no. 1 (2016): 15.

[22] Zahroya, Isyvina Unai. "RESPONS PERUKYAT METODE TRADISIONAL DAN SAINS DALAM KEBERHASILAN RUKYAT AL-HILĀL AHMAD ASYHAR SHOFWAN." Tesis, UIN Walisongo Semarang, 2022.

for integration and recognition from religious and astronomical authorities to recognize this system as official observation evidence.[23]

The hilal tracker has become a useful educational tool in astronomical training, as seen from its application in the practical curriculum in various Islamic universities and Islamic boarding schools; lecturers and teachers use this system to explain the basics of observing the crescent moon, coordinate data, horizon height, and astronomical time, which were previously only taught in theoretical form; this shows a shift from a cognitive approach to a more practical approach and direct experience.

At the community level, the hilal tracker strengthens cooperation between observers, both domestically and internationally; for example, reports from users in Malaysia, Brunei, and Singapore are now starting to mention the *hilal* tracker as a reference for their location, indicating community-based regional standardization; this phenomenon opens up opportunities to build an observation network between countries that can be used in an integrated global *Hijri* calendar.[24]

The hilal tracker in astronomical education is not only limited to classroom teaching, but has also touched on project-based learning activities that allow students and pupils to conduct direct *hilal* observations with the support of this application as the main tool; This activity is carried out in various institutions such as UIN, IAIN, and Islamic boarding schools that have an interest in the development of Islamic astronomy; in this practicum, the *hilal* tracker is used starting from observation planning, searching for the best point, mapping the area, to recording *rukyat* data in a neatly arranged digital format.

Furthermore, the *hilal* tracker has the potential to be applied in cross-disciplinary projects such as an early warning system for extreme weather based on the western horizon, mapping places of worship with open sky access, and observing natural phenomena. This tool can develop into a comprehensive night hilal information center for Muslim communities worldwide.[25]

Since the beginning of the development of Islam, astronomy has contributed greatly, where the Prophet Muhammad PBUH encouraged Muslims to explore various sciences, including astronomy, to deepen their understanding of the universe and time. In this context, the crescent moon becomes a vital object of observation to mark various important events in the lives of Muslims.[262] The Qur'an also highlights the role of the moon and other celestial bodies in several of its verses, one of which is in the lives of Muslims. The Qur'an also highlights the role of the moon and other celestial bodies in several verses, one of which is in Surah Al-Baqarah (2:189).

> They asked you (Prophet Muhammad) about the crescent moon. Say, "That is (indicator of) the time for humans and (the pilgrimage of) Hajj." It is not virtuous to enter a house from behind it, but it is virtuous (virtue) of those who are pious. Enter houses from their doors, and fear Allah so that you may succeed.

Surah Al-Baqarah verse 189 has a deep meaning, showing Islam's harmonious relationship between natural phenomena and spiritual values . This verse begins with a question from some of the companions of the Prophet Muhammad PBUH regarding the phenomenon of the crescent moon (al-ahillah). They wanted to know why the moon changed shape from small to large and then

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[23] Suhardiman. "Kriteria Visibilitas Hilal dalam Penetapan Awal Bulan Kamariah di Indonesia." *Journal Of Islamic Studies* 3, no. 2 (2013).
[24] Wasilah Wahidin, N. "Problematika Penyatuan Kalender Hijriyah." *Jurnal Ilmu Falak dan Astronomi* 4, no. 2 (2022): 275–283.
[25] Mulyadi, A. "Kalender Ritual Masyarakat Muslim Sumenep Madura." *NUANSA: Jurnal Penelitian Ilmu Sosial Dan Keagamaan Islam* 9, no. 1 (2012).
[26] Yulia Rahmadani Hudayah, Rahma Amir. "Pandangan Mui Terkait Perbedaan Penetapan 1 Syawal 1444 H Di Indonesia." *Elfalaky* 7, no. 1 (2023): 89–104.

disappeared again, and whether there was a certain meaning behind the change in religion. Allah SWT answered this question by revealing a clear verse. In this explanation, it can be concluded that the crescent moon does not exist without a specific purpose, but rather has an important role in human life, namely as a time regulator, both for worldly aspects such as trade and social interaction, as well as for worship such as fasting and hajj.

By mentioning that the crescent is *mawāqīt li al-nās wa al-ḥajj*, Allah explains that the movement of the moon functions as a method for calculating time and establishing the Islamic calendar. The role of the crescent moon shows how much Islamic law pays attention to punctuality, as well as the importance of precise calculations in carrying out worship that depends on time, such as determining the beginning of Ramadan, Eid al-Fitr, Dzulhijjah, and performing the Hajj pilgrimage. Behind this explanation, there is an encouragement for Muslims to study the science of astronomy (Islamic astronomy) to understand the signs of Allah's greatness in the sky and apply it in proper and scientific religious practices.

In the second part of this verse, it suddenly shifts from a discussion of astronomy to ethical behavior by criticizing the habits of some ignorant Arabs. When someone was in a state of *ihram*, they felt it was inappropriate to enter the house through the front door because it was considered dishonorable, so they chose to enter through the back door. Allah SWT emphasizes that this behavior is not a form of goodness (*al-birr*), but rather a wrong culture and has no basis in religion. According to this verse, the essence of true goodness does not lie in physical appearance or artificial ritual symbolism, but in sincerity in fearing Allah.

Therefore, this verse also serves as a correction to the misunderstanding regarding the meaning of worship. Allah reminds us that entering a house should be through the door, not from the back. This statement has both literal and symbolic meanings. Actions in life must be carried out legitimate, honest, and normative. While symbolically, this verse teaches that in living life and worshiping, everyone needs to follow the right path and not take a deviant or unreal path. Allah closes this verse with the command, "Be pious to Allah so that you will obtain sustenance", emphasizing that piety is the main foundation for achieving spiritual and social success in human life.

From an interpretive perspective, religious scholars provide clarifications that strengthen this meaning. Imam al-Ṭabarī stated that the change in the shape of the crescent moon is one of the signs of time that Allah has determined as a reference in worship and human life. Tafsir Ibn Kathir emphasized that the crescent moon was not created without a purpose or only to beautify the sky, but as a tool for determining time, so it must be respected seriously. Al-Qurṭubī explains that entering a house through the door symbolizes obedience to the law and norms, and is part of Islamic manners in behavior.

This verse is also the basis for developing various disciplines in Islam, especially astronomy. Therefore, scholars use this verse as evidence in determining laws related to observing the crescent moon and determining the Hijri calendar. In the current context, this verse is relevant to current issues such as the creation of a global Hijri calendar, technology in observing the crescent moon, and adjustments to religious practices that are influenced by local culture but do not comply with Sharia principles. This verse also provides a valuable lesson for Muslims not to get caught up in ritual practices that are not based on revelation, but to return to the core teachings of Islam, which emphasize knowledge, manners, and piety.

As a summary, Surah Al-Baqarah verse 189 teaches Muslims to always use science and the Shari'a as the basis for understanding natural phenomena and carrying out worship. This verse also instructs not to focus on symbols or habits with no basis, and emphasizes that the essence of goodness is piety, not just external appearances. Entering the house through the door is a strong metaphor for

always following a legal, straight path and following norms in this worldly life and the hereafter. By adhering to piety, happiness and salvation will be achieved, as promised at the end of the verse: "wa-ttaqullāha laʿallakum tufliḥūn".

During the time of the Prophet Muhammad PBUH, Muslims observed the crescent moon directly, with the help of companions who had special abilities in observing the moon's position in the sky. Ibn Umar was one of the companions famous as a crescent observer. In several hadiths, the Prophet Muhammad reminded his people to observe the crescent moon as a sign of the beginning of the month. The Hijri calendar, a lunar calendar used by Muslims, began with the *hijrah* of the Prophet Muhammad PBUH. Unlike the Gregorian solar calendar, this calendar relies on observing the crescent moon to determine the new month. Therefore, each month in the Islamic calendar begins with the appearance of the crescent moon.[27]

In the tradition of *fiqh* (Islamic law), astronomy, especially the observation of the crescent moon, plays a crucial role in determining the times of worship. The scholars of *fiqh* need information about the beginning of the month to set the times of worship correctly. Interaction between astronomy and fiqh often takes place to regulate various rituals based on the lunar calendar.[28] In the Middle Ages, Muslim scientists such as Al-Battani and Al-Farghani made a major contribution to astronomy, using observations of the new moon as a basis for calculating time in the lunar calendar. They also formulated scientific theories regarding the movement of celestial bodies, including the moon and sun.[29]

The sighting of the crescent moon, the first crescent of the moon after the new moon, has significant significance in Islamic astronomical tradition. In a religious context, the crescent moon marks the beginning of the month in the Islamic calendar, which is used to determine important times for Muslims, such as Ramadan and Eid al-Fitr. The practice of determining the beginning of the month by observing the crescent moon has been going on for centuries, since the time of the Prophet Muhammad, who became the basis for Muslims in determining the beginning of the month.[30] Initially, crescent sightings were done using the naked eye or simple astronomical instruments. Observers would look for the first crescent moon to appear in the sky as a sign of the start of the new month. However, this observation was not always easy, given the limited equipment available and factors such as weather and light pollution that could obstruct the view. Furthermore, crescent sightings were also greatly influenced by the location of the observation, which varied from region to region, leading to differences of opinion regarding determining the beginning of the month, known as "ru'yat al-hilal" (crescent sighting) in different countries or Islamic communities.

In a religious context, the Qur'an emphasizes the importance of observing the crescent moon as a guide in determining time, especially for the months of the Hijri calendar, such as Ramadan and Shawwal. Therefore, technology such as the Hilal Tracker can be considered a tool that increases the accuracy and efficiency of observing the moon, which has been prescribed in Islam.[31]

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[27] Yulia Nurunnadhiroh. " Analisis Keberhasilan Melihat Hilal Menggunakan Alat Gawang Lokasi Versi Pondok Pesantren Manba ' Ul Hikam Sidoarjo." Skripsi Sarjana, UIN Walisongo Semarang, 2020.

[28] A Mulyadi, A. "Analisis Lokasi Pengamatan Hilal Di Jawa Madura Dan Pengaruhnya Terhadap Keberhasilan Rukyatul Hilal." Braz Dent J 33, no. 1 (2022): 1–12.

[29] Nur Afny Awwalany, Sippah Chotban, Subhan Khalik. "Peluang dan tantangan ilmu falak di indonesia era digital." *Hisabuna* 4, no. 3 (2023): 129.

[30] Mukhammad Ainul Yaqin. "Analisis Metode Pengolahan Citra Hilal Lembaga Penerbangan Dan Antariksa Nasional (Lapan) Pasuruan Perspektif Fiqh Dan Astronomi." Skripsi Sarjana, UIN Walisongo Semarang, 2019.

[31] Zufriani. "Hisab Dan Rukyat Serta Pengaruhnya Terhadap Kesatuan Umat Islam: Analisis Dampak Dan Solusi." 14, (2016): 141–169.

Here are some relevant verses in the Qur'an, Surah Yunus (10:5):

> He is the one who makes the sun shine and the moon shine. He also determined the orbital locations, so you know the number of years and calculations (time). Allah does not create like that, except correctly. He explains the signs (of His greatness) to a people who know.

Scientifically and spiritually, this verse explains the role of the sun and the moon in human life, where the sun is referred to as "ḍiyā'an" (light provider), while the moon is "*nūran*" (light receiver). The choice of these two terms is very appropriate in describing the current physical reality: the sun is a celestial object that emits its light through nuclear fusion, while the moon does not produce light but reflects light from the sun. The Qur'an has revealed a scientific fact that humans only learned thousands of years after this verse was revealed.

Furthermore, Allah states that He has determined the positions of the moon, the phases of the moon's crossing from the crescent to the full moon and back to the crescent. This process consists of about 28 stages, which in astronomy are known as *manāzil al-qamar*. These phases are the basis for the Hijri calendar and are essential in determining the times of worship in Islam, such as the beginning of Ramadan, Eid al-Fitr, Eid al-Adha, and others. In this case, the Qur'an teaches that the calculation of time is not a human creation, but rather a system created by Allah for the good of mankind so that they can live their lives in an orderly and directed manner.

Surah Yunus verse 5 describes celestial phenomena and a theological statement rich in scientific and ethical meaning. In this verse, Allah SWT emphasizes that everything in the universe, including the orderly orbits of the sun and moon, is not just a coincidence, but a creation full of calculation and contains values of truth (*al-haqq*). Every element of the cosmos functions to maintain balance and support human life on Earth. By making the sun a source of light that illuminates the Earth and the moon a time marker that undergoes regular changes in shape, Allah teaches humans that order and precision are part of His provisions.

The importance of understanding time in Islam is seen in the phrase لِتَعْلَمُوْا عَدَدَ السِّنِيْنَ وَالْحِسَابَۗ (for you to know the number of years and calculations). In this case, time not only functions as a chronological measure, but also as a moral and spiritual benchmark. Islam teaches that time should be used to do good, reflect, learn, and improve oneself. Thus, the moon's role in the Hijri calendar is not only an administrative matter, but also part of worship and awareness of the cycle of human life. In Islam, time is also closely related to the commands of the Shari'a: the times of prayer, fasting, and hajj all depend on observations of the movements of the sun and moon.

In addition, this verse is the basis of thought in Islamic science, especially in astronomy. In the history of classical Islamic civilization, this verse inspired the development of astronomy. Famous figures such as al-Battani, al-Farghani, and al-Biruni used verses like these as motivation to create accurate methods of calculating time, observing the stars, and compiling calendars. They did not separate knowledge from faith, and scientific observation from theological reflection. The Qur'an provides moral guidance and an endless source of scientific inspiration.

From the perspective of cosmic Sufism, this verse is also a source of deep spiritual reflection. Sufis consider the rotation of the sun and moon as a manifestation of the order and obedience of creatures to God's commands. No celestial body deviates from its path or acts arbitrarily. Therefore, humans, as creatures endowed with reason and freedom, should feel more ashamed if their lives are not orderly or not under divine rules. Seeing the orderly and harmonious phenomena of the sky, the human soul should be inspired to return to the path of God.

In addition, this verse subtly teaches the importance of balance between light and darkness. The sun radiates light during the day and provides life, while the moon shines softly at night. Both function alternately without colliding with each other. Humans need to find a balance between activity and

rest, between light and dark, and between work and reflection. Deeper still, the regularity of the moon's phases teaches about the process, development, and transformation, where each stage has wisdom and purpose. Thus, human life is a gradual process that cannot be forced or skipped.

The relevance of this verse in the current context is also very significant. In the fast-paced and digital modern era, many people forget the natural cycle and rely entirely on the time created (digital clocks and calendars). Allah has created a more natural and harmonious time system by moving the moon and the sun. Returning to the Hijri calendar based on the crescent moon, as stated in this verse, can be a form of obedience to the *sunnatullah* and a strategic step to strengthen the unity of Muslims globally. This verse is a solid theological and scientific basis, especially in discussing the Single Global Hijri Calendar.

The conclusion of this verse, which reads " يُفَصِّلُ الْاٰيٰتِ لِقَوْمٍ يَّعْلَمُوْنَ ", emphasizes that only individuals who have knowledge and are willing to use it can understand and absorb Allah's messages from natural phenomena. It shows how the Qur'an emphasizes the importance of knowledge and reason to understand reality. It is where the important role of Islamic education appears, which needs to connect the verses of kauniyah (natural phenomena) with the verses of qauliyah (revelation), to produce a generation that is not only devout in religion, but also excels in science and technology, with the intention of worship.

Thus, Surah Yunus verse 5 becomes one of the foundations of Islamic thought that integrates monotheism, science, spirituality, and social order elements. It not only directs humans to know the Creator through His creation, but also teaches how to use nature wisely and appreciate time as something sacred and meaningful. In the movement of the sun and the moon, there is a profound lesson about submission, discipline, precision, and the greatness of God's law that encompasses the entire universe. Therefore, whoever submits to this rule is the one who will receive blessings both in this world and in the hereafter.

Surah Al-Isra' (17:12):

We made night and day two signs (of our greatness). We abolished the signs of the night and made the signs of the day bright and clear so that you (can) seek grace from your Lord and know the number of years and the reckoning (of time). We have explained everything in detail.

This verse describes how Allah created night and day as two clear signs. In Arabic, "āyah" means guidance, evidence, or miracle. Thus, night and day are natural phenomena and signs of Allah's power, order, and wisdom governing the universe. Both remind humans that life follows a harmonious cycle: light and darkness, activity and rest, work and rest, hope and reflection. Night and day do not happen by chance but are a regular and meaningful system.

When Allah states that "We erase the sign of the night," commentators explain that this refers to the diminishing light of the moon at night, in contrast to the day filled with bright sunlight. An interpretation also sees the night sky as a symbol of tranquility and secrecy, while the day indicates clarity and activity. Thus, Allah deliberately created a night so humans have time to rest and reflect, while the day was created with light so that humans can see clearly and carry out productive activities.

The statement "وَجَعَلْنَآ اٰيَةَ النَّهَارِ مُبْصِرَةً" (and We made the signs of the day bright) confirms that Allah gives the ability to see and light during the day, which makes it easier for humans to work, earn a living, interact socially, and fulfill the needs of life. In this verse, there is an implied command to strive and work, as written: "لِّتَبْتَغُوْا فَضْلًا مِّنْ رَّبِّكُمْ", which means "so that you seek mercy from your Lord". This phrase shows that work includes worship; the day is Allah's time to carry out these activities.

Furthermore, this verse also confirms that the existence of night and day helps humans in knowing the number of years and calculating time: وَلِتَعْلَمُوْا عَدَدَ السِّنِيْنَ وَالْحِسَابَۗ This confirms that the calendar system, whether based on the moon or the sun, basically depends on the cycle of night and day. Humans need a clear time system to carry out worship, contracts, transactions, administration, and even manage social life. Therefore, this verse also became the theological basis for the development of Islamic astronomy, the science of time, and the Hijri and Shamsiyah calendars, which are still used in various aspects of the lives of Muslims today.

This verse also implies that the universe was created with laws that can be studied and explored, as it ends with the sentence وَكُلَّ شَيْءٍ فَصَّلْنٰهُ تَفْصِيْلًا "and all things have We explained in detail". It is an invitation to think scientifically, explore knowledge, and investigate Allah's creation, rather than passively accepting natural phenomena. In this context, the Qur'an is a moral guidebook and a source of knowledge that inspires exploration and innovation based on monotheism.

From a spiritual aspect, this verse raises awareness that human life is also trapped in a balanced cycle of duality. Like night and day, humans experience joy and sorrow, health and sickness, strength and weakness. Allah created night and day not to be worshipped, but as a medium to recognize Him, through experiencing the order and function of His creation. Therefore, this verse fosters a sense of trust and gratitude and the spirit to live with a balance between work and worship, worldly life and the hereafter.

In the current context, this verse is relevant amidst the trend of life that ignores natural balance. Many modern people are trapped in endless routines, forgetting night as a time to rest, and making night feel like day due to advances in lighting technology. This activity affects physical health and disrupts humans' biological and spiritual cycles. By understanding this verse, Muslims are invited to return to a way of life that is in harmony with the *sunnatullah*, maintaining the balance of the daily rhythm that Allah has determined since the creation of the universe.

This verse can also be interpreted as an important basis in preparing public policies based on divine time, such as scheduling educational activities, regulating work hours, and even a national calendar that integrates the solar and lunar calendars. In the Islamic education sector, this verse teaches that calculating time is not just a technical tool, but rather part of manners towards time as a trust from Allah, for which we will be held accountable.

In conclusion, Surah Al-Isrā' verse 12 reveals that night and day are astronomical phenomena and signs of Allah's power and wisdom with spiritual, social, and scientific dimensions. Both were created for the good of humans: night for tranquility and reflection, day for vision and effort. Through this cycle, Allah instills in humans a sense of time, a drive to work, a sense of gratitude, and a motivation to think and act according to His laws and purposes. By understanding and internalizing this verse, humans will live more orderly lives and grow closer to Allah, the All-Powerful Arranger of all things.

Based on all the analysis presented in this section, Hilal Tracker has had a significant role in recording the development of hilal observation locations regularly since 2015 until now. This project not only documents rukyat locations, but also pays attention to the complexity of the situation in the field, such as policy changes, technical adjustments, and responses to existing geographical and atmospheric conditions. With digitally documented data, Hilal Tracker is a symbol of the joint efforts of hilal observers to improve accuracy, transparency, and cooperation in determining the beginning of the Hijri month. Annual location mapping consistently selects strategic areas that meet visibility criteria, such as low light pollution, sufficient elevation, and unobstructed western views.

In its implementation, Hilal tracker managers actively change observation methods based on the challenges faced at each rukyat location, whether related to weather, environmental disturbances, or

limitations of available equipment. The findings also showed that observers from various institutions are increasing, including religious institutions, universities, and independent *Falakiyah* communities. Hilal tracker creates an opportunity for dialogue between hisab and rukyat experts, because the recorded data can be tested, verified, and used as a reference in *isbat* sessions or academic discussions. Wider dissemination of information is also achieved through the developed online platform, so that other observers can access strategic locations for collaboration or joint data verification.

From year to year, there has been an increase in tools such as telescopes, DSLR cameras, and drones, which shows more technology in supporting observations. Hilal Tracker has successfully connected traditional and modern methods in a balanced way. Comparisons between locations also provide an objective basis for evaluation of the effectiveness of each rukyat point based on weather conditions, horizon, and elevation. From a methodological perspective, Hilal Tracker contributes to ethnographic and qualitative approaches in Islamic astronomy.

Furthermore, Hilal Tracker creates a more integrated and collaborative Hilal observation ecosystem by transparently involving various stakeholders. This inter-regional collaboration results in shared learning about location quality, observation time management, and evaluation of the tools used. Amidst the challenges of globalization and differences in methods in determining the Hijri calendar, Hilal Tracker is present as a field data-based solution that allows the application of a scientific approach in determining the beginning of the month. It is also important to note that Hilal Tracker provides opportunities for further research in crescent visibility, atmosphere, and software development in Islamic astronomy.

It makes Hilal Tracker descriptive, analytical, and predictive. In the long term, if used optimally, this system can be the basis for compiling a more accurate and widely accepted Hijri calendar at the national and international levels. Hilal Tracker in various decision-making forums shows the increasing trust from various parties in the integrity and reliability of the data presented.

Finally, this section of results and observations clearly shows that Hilal Tracker is more than just location determination, but also reflects changes in the understanding of science in contemporary Islamic astronomy. This system connects geographical dots and unites Muslims' thoughts, methods, and hopes to align knowledge and beliefs. With its continuously evolving and updated records, Hilal Tracker has proven itself an important innovation in community-based crescent sighting, collaboration, and scientific integrity. Therefore, this study underlined that Hilal Tracker is a real representation of the collaboration between classical astronomical traditions and modern scientific technology and spirit, and is a significant contribution to the current efforts towards a precise, integrated, and accountable Hijri calendar.

Conclusion

Hilal Tracker is a digital system designed to document and analyze crescent moon observation locations since 2015. This system was created to improve accuracy and efficiency in determining the beginning of the Hijri month. The data collected includes geographic location, time, weather conditions, and observation results. This facility allows differences in *rukyat* reports to be tracked scientifically and transparently. Hilal Tracker has been implemented in various regions to find the best place to observe the crescent moon. This system supports decision-making related to the Islamic calendar with a more data-driven approach. Hilal Tracker combines astronomy, information technology, and meteorology in one platform. Since 2020, this system can be accessed via mobile devices, simplifying the reporting process in the field. Users can upload photos of the crescent moon, fill out forms, and record weather conditions directly. It increases community participation and

improves the quality of the data received. Hilal Tracker is also an educational tool in observatories and Islamic educational institutions. This system plays a role in building a sustainable and scientifically explainable Hilal data archive.

The data plays an important role in assessing the visibility of the *hilal* model and the ideal location. Hilal Tracker also encourages cooperation between astronomers, scholars, and government agencies. This system helps reduce differences in decisions about the beginning of the month that often occur in society. Hilal Tracker is one example of hilal observation that can be carried out with a modern approach without losing Sharia values. The Hilal can provide warnings more accurately, scientifically, and responsibly through this innovation. This system also builds discussions about the global Hijri calendar based on scientific data and methodology. Hilal Tracker significantly contributes to bridging traditional *rukyat* with more contemporary hisab methods. With further development, this system can potentially become an international standard in Hilal observation. Overall, Hilal tracking proves that the integration of science, technology, and Sharia can produce the right solution for the lives of Muslims.

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