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Analysis of Perigee-Apogee Longitude Classification with Crescent Visibility Years 1300H-1600H Based on New MABIMS Criteria

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Abstract: The determination of the beginning of the Hijri month in Indonesia still faces inconsistencies due to the complexity of astronomical parameters. This study analyzes the classification pattern of the Moon's perigee-apogee longitude position in relation to the visibility level of the crescent moon during the 1300H-1600H period to provide an in depth understanding of the orbital factors in determining the beginning of the Hijri month in Indonesia. A descriptive quantitative method was used by analyzing 10,836 data from three locations (Sabang, Surabaya, and Merauke) using astronomical algorithms from Chapront-Touze & Jean Meeus based on the New MABIMS and Odeh criteria. The results show that crescent visibility frequency at the apogee position is higher than at perigee under both criteria, with New MABIMS recording 1,314 apogee compared to 163 perigee cases, and Odeh recording 1,113 apogee compared to 127 perigee cases. New MABIMS consistently yielded higher overall visibility rates (4,539 cases) than Odeh (2,353 cases), a difference statistically confirmed through a chi-square test of independence across all three cities (p<0.001). The data distribution pattern is relatively consistent across the three locations, with orbital factors proving more dominant than geographical factors in determining crescent visibility. This study provides an initial overview that the Moon's orbital dynamics have the potential to provide additional context in crescent observations. Empirical validation through actual observation data and the integration of atmospheric factors are needed to produce a more comprehensive and applicable understanding.
Keywords: *Classification, Perigee, Apogee, Crescent Visibility*

Abstrak: Penentuan awal bulan Hijriah di Indonesia masih menghadapi inkonsistensi karena kompleksitas parameter astronomi. Studi ini menganalisis pola klasifikasi posisi bujur perigee-apogee Bulan dalam kaitannya dengan tingkat visibilitas hilal pada periode 1300H-1600H untuk memberikan pemahaman mendalam tentang faktor orbital dalam menentukan awal bulan Hijriah di Indonesia. Metode deskriptif kuantitatif digunakan dengan menganalisis 10.836 data dari tiga lokasi (Sabang, Surabaya, dan Merauke) menggunakan algoritma astronomi dari Chapront-Touze & Jean Meeus berdasarkan kriteria New MABIMS dan Odeh. Hasil menunjukkan bahwa frekuensi visibilitas hilal pada posisi apogee lebih tinggi daripada pada perigee di bawah kedua kriteria, dengan New MABIMS mencatat 1.314 kasus apogee dibandingkan dengan 163 kasus perigee, dan Odeh mencatat 1.113 kasus apogee dibandingkan dengan 127 kasus perigee. New MABIMS secara konsisten menghasilkan tingkat visibilitas keseluruhan yang lebih tinggi (4.539 kasus) daripada Odeh (2.353 kasus), perbedaan yang secara statistik dikonfirmasi melalui uji chi-square independensi di ketiga kota tersebut (p<0,001). Pola distribusi data relatif konsisten di ketiga lokasi, dengan faktor orbit terbukti lebih dominan daripada faktor geografis dalam menentukan visibilitas hilal. Studi ini memberikan gambaran awal bahwa dinamika orbit Bulan berpotensi memberikan konteks tambahan dalam pengamatan hilal. Validasi empiris melalui data pengamatan aktual dan integrasi faktor atmosfer diperlukan untuk menghasilkan pemahaman yang lebih komprehensif dan aplikatif.
Kata kunci: *Klasifikasi, Perigee, Apogee, Visibilitas Hilal*

A. Introduction

The determination of the beginning of the Hijri month in Indonesia faces increasingly complex astronomical problems. In 2023, there was a difference in the determination of 1 Shawwal 1444

AH, with Muhammadiyah setting the date as April 21, while the government set it as April 22.[1] In determining the first day of Ramadan 1445 H, BMKG data showed that the elongation across Indonesia ranged from 1,64° to 2,08°. Based on the new MABIMS criteria, these conditions indicate that the crescent moon is unlikely to be visible across Indonesia.[2] BRIN estimates that in determining the start of Ramadan 1446 H, there is a high potential for rukyat failure because in most regions of Indonesia the crescent moon does not meet the minimum Neo MABIMS criteria. Although Banda Aceh slightly exceeded the criteria with an altitude of 4.5° and elongation of 6.4°, other regions such as Surabaya only recorded an altitude of 3.7° with elongation of 5.8°, which remains below the threshold.[3] Nevertheless, the Indonesian government successfully determined the start of Ramadan 1446 H on Saturday, March 1, 2025, based on the testimony of two witnesses who saw the crescent moon in the Aceh region.[4] According to Prof. Thomas Djamaluddin,[5] the criteria for crescent visibility need to be dynamic and open so that they can be continuously refined through the latest scientific data, thereby bridging the differences between hisab and rukyat in determining the Hijri calendar in Indonesia.

Research on crescent visibility for determining the start of the Hijri month shows a diversification of approaches that can be categorized into five main areas of study. First, the development of artificial intelligence and machine learning technologies that produce highly accurate predictive models.[6][7][8] Second, the implementation of digital image processing and computer vision technologies to optimize visual detection of the crescent moon.[9][10][11] Third,

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[2] Kompas.id, “Jelang Sidang Isbat, Hilal Awal Ramadhan 1445 H Sulit Diamati Di Indonesia,” Kompas.Id, March 10, 2024, https://www.kompas.id/baca/humaniora/2024/03/10/hilal-awal-ramadhan-14452024-sulit-diamati-di-indonesia.

[3] Liputan6.com, “BRIN Sebut Potensi Gagal Rukyat Cukup Besar, Awal Ramadan 2025 Bisa Berbeda,” Liputan6.Com, February 23, 2025, https://www.liputan6.com/news/read/5931772/brin-sebut-potensi-gagal-rukyat-cukup-besar-awal-ramadan-2025-bisa-berbeda?page=3.

[4] Kemenag.go.id, “Pemerintah Tetapkan 1 Ramadan 1446 H Jatuh Pada 1 Maret 2025,” Kemenag.Go.Id, February 28, 2025, https://kemenag.go.id/pers-rilis/pemerintah-tetapkan-1-ramadan-1446-h-jatuh-pada-1-maret-2025-YzheO.

[5] Thomas Djamaluddin, “Redefinisi Hilal Menuju Titik Temu Kalender Hijriyah,” WordPress, 2010, https://tdjamaluddin.wordpress.com/2010/06/22/redefinisi-hilal-menuju-titik-temu-kalender-hijriyah/.

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[8] 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.

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[10] Muhammad Fajri Kholili Zain et al., “Shari’ah Standardization of Astrophotography for Rukyatul Hilal,” *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 11, no. 2 (2025).

[11] A.N. Zulkeflee et al., “Detection of a New Crescent Moon Using the Maximally Stable Extremal Regions (MSER) Technique,” *Astronomy and Computing* 41 (2022), https://doi.org/10.1016/j.ascom.2022.100651.

analysis of theoretical models and classical visibility criteria based on fundamental astronomical parameters.[12][13] Fourth, validation of methodologies and standardization of crescent observation procedures that reveal data quality issues and calculation inconsistencies.[14][15][16][17][18] Fifth, the evaluation of the practical implementation and systemic impact of visibility criteria on the Islamic calendar shows the complexity of application in the field.[19][20][21][22][23][24] A semantic literature review by Muh. Rasywan Syarif[25] confirms the evolution of research from classical methods to modern approaches based on cutting-edge computational technology. However, research that specifically analyzes the classification between lunar orbital factors such as perigee and apogee longitude against elongation parameters using long

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[15] Muhammad Syarief Hidayatullah and Desy Kristiane, "Fikih Falakiyah Perspektif Teori Astronomi: Analisis Tinggi Hilal Dari Segi Koreksi Semidiameter Bulan," *El-Falaky: Jurnal Ilmu Falak* 6, no. 2 (2022): 315–30, https://doi.org/10.24252/ifk.v6i2.33478.

[16] Isroqunnajah et al., "Uji Sahih Observasi Hilal Siang Hari dengan Hisab Hakiki Kontemporer Sistem Ephemeris Al-Falakiyah," *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan* 8, no. 2 (2022), https://doi.org/10.30596/jam.v8i2.10703.

[17] Hariyadi Putraga et al., "Uji Efektivitas Teleskop iOptron Cube-G untuk Pengamatan Hilal," *AL - Afaq : Jurnal Ilmu Falak dan Astronomi* 4, no. 2 (2022): 219–36.

[18] Novi Sopwan et al., "Astronomical Analysis of Hilal Testimony Data: A Comprehensive Study of the Ministry of Religious Affairs of the Republic of Indonesia from 1962 – 2021," *AL - Afaq : Jurnal Ilmu Falak Dan Astronomi* 6, no. 1 (2024), https://doi.org/10.20414/afaq.v6i1.9810.

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[20] 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.

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[22] Ridhokimura Soderi et al., "Rekontruksi Kriteria Visibilitas Hilal Serta Dampak Implementasi Kriteria Imkanurukyah MABIMS Baru Dalam Kemaslahatan," *Astroislamica: Journal of Islamic Astronomy* 3, no. 2 (2024): 233–55, https://doi.org/10.47766/astroislamica.v3i2.3642.

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[25] 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.

term historical data is still unavailable, even though this analysis is crucial for optimizing the accuracy of crescent visibility predictions based on orbital parameters.

This study aims to complement previous studies that have not analyzed in depth the influence of lunar orbital parameters on the accuracy of crescent visibility predictions in determining the beginning of the Hijri month in Indonesia. Specifically, this study reveals the classification between the moon's perigee and apogee longitude and the level of crescent visibility using historical data from the 1300H-1600H period. Thus, two questions can be formulated: First, what is the pattern of crescent visibility classification based on variations in the moon's perigee and apogee longitude in the 1300H-1600H period? Second, how does the classification analysis between the moon's perigee-apogee longitude and the visibility level of the crescent moon in the 1300H-1600H period? Understanding the classification pattern between orbital parameters and crescent moon visibility makes it possible to develop a more accurate prediction model that can be used as a reference in supporting the harmonization of determining the beginning of the Hijri month in Indonesia.

Determining the beginning of the Hijri month in Indonesia faces challenges in prediction accuracy that have not been fully addressed by previous studies, which have focused more on the development of artificial intelligence technology and classical visibility criteria. This research is based on three main arguments: first, the lack of exploration of the influence of lunar orbital parameters such as perigee and apogee longitude on the level of crescent visibility; second, the need for empirical correlation analysis based on long-term historical data to identify patterns that can improve prediction reliability, given the problem of inconsistency in determination that still occurs; third, the urgency of developing a prediction model that can contribute to the standardization of the methodology for determining the beginning of the Hijri month in Indonesia. Thus, the analysis of the classification of lunar orbital parameters with crescent visibility for the 1300H-1600H period is expected to fill the existing research gap and provide an empirical basis for optimizing the accuracy of predictions in determining the beginning of the Hijri month.

B. Method

This research is a literature study with a qualitative approach that analyzes the pattern of crescent visibility classification against the position of the Moon's perigee and apogee longitude in the 1300H-1600H time range. A descriptive-quantitative approach was chosen to identify distribution patterns and frequency of crescent visibility at different orbital positions through numerical astronomical data analysis.[26] The research locations were focused on three cities in Indonesia, namely Sabang (05°54'22" N, 95°13'01" E), Surabaya (07°15' S, 112°45' E), and Merauke (08°30'55" S 140°24'55" E), which were selected based on their geographical representation of Indonesia from west to east. The selection of these three locations took into account the differences in sunset times and geographical latitude, with Sabang representing the western region with longer observation times, Surabaya representing the central region with

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[26] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, Dan R&D* (Alfabeta, 2013), 30.

adequate observation infrastructure, and Merauke representing eastern Indonesia with earlier sunset times.

The primary data in this study was sourced from the results of crescent visibility classification calculations using astronomical algorithms from two main references: the book "*Lunar Tables and Programs from 4000 B.C. to A.D. 8000*" by Michelle Chapront Touze and Jean Chapront to obtain data on the lunar perigee and apogee positions, and "*Astronomical Algorithms*" by Jean Meeus for computing the positions of the Moon and Sun. Secondary data was obtained from the calculation of crescent visibility in Microsoft Excel format, which was then analyzed to identify the distribution pattern of the research data. Operationally, data collection used a documentation method applied to the 1300H 1600H period at three research locations. The data was then selected and categorized based on the classification of perigee-apogee longitude, crescent visibility level, and geographical location of observation according to predetermined criteria. The classified data was compiled in tabular form and then analyzed using descriptive-quantitative methods through systematic stages: collecting data on the position of the perigee-apogee and crescent visibility, classifying the results of the perigee and apogee longitude calculations, comparing the perigee and apogee longitudes based on the multi-parameter values of crescent visibility to describe the distribution pattern, conducting a chi-square test of independence to statistically confirm the difference in visibility outcomes between the New MABIMS and Odeh criteria, and concluding the classification analysis results to describe the relationship pattern between the perigee and apogee longitudes and crescent visibility.

C. Result and Discussion

Research Results

1. Concept of Perigee and Apogee Longitude

In its movement around the Earth, the Moon has two extreme points in its orbit. Perigee is the closest point in the Moon's orbit around the Earth. Meanwhile, apogee is the furthest point in the Moon's orbit around the Earth. On average, the Moon orbits the Earth at a distance of approximately 382,900 kilometers. However, this distance varies throughout its orbit. At the perigee point, the Moon is about 363,104 km from Earth, while at the apogee point, the distance reaches 405,696 km. In terms of longitude, the Moon's position at perigee is generally marked by a value of 180°, while at apogee it is marked by a value of 0° and 360°.[27] The classification of crescent visibility based on perigee-apogee longitude is a grouping of data from the calculation of crescent visibility within the time frame of 1300H-1600H, while also grouping the ranges of perigee and apogee longitude.

In calculating the visibility of the crescent moon and the Moon's perigee-apogee longitude, the author divides the Moon's longitude range in its orbit into several groups. The range starts from 0° to 360°, with intervals of 30°. For notational consistency, each longitude range in this study is written from the smaller to the larger value. The range 15°–345° denotes

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[27] Muhammad Alwi Musyafa, "Pengaruh Posisi Perigee Dan Apogee Bulan Terhadap Visibilitas Hilal" (Skripsi, Universitas Islam Negeri Sunan Ampel, 2023), 73, http://digilib.uinsa.ac.id/64823/.

a 30° interval crossing the 0° longitude. This division starts from the range of 15° – 345°, which represents the middle position of the longitude 0° and 360°. The range 15° – 45° represents 30° longitude, the range 45° – 75° represents 60° longitude, and so on, with each 30° range describing the change in the Moon's position in its orbit. In the Moon's orbit, the perigee position occurs when the distance of the Moon's longitude from the perigee longitude is at 0° and 360°, while the apogee position occurs when the distance of the Moon from the perigee longitude reaches 180°.[28] The longitude range used as a reference for the perigee phenomenon is 15° – 345°, while for the apogee phenomenon, the orbital reference is in the range of 165° – 195°.

2. Classification of Crescent Visibility and the Moon's Perigee-Apogee Position in the Cities of Sabang, Surabaya, and Merauke

The author has classified the crescent visibility data and the longitude of the perigee-apogee for each city at sunset. The calculation data in this study represents positive crescent visibility only, as the computation was specifically designed to generate data for conditions where the crescent moon is above the horizon at sunset. This approach is consistent with the research objective of analyzing visibility classification patterns at the beginning of the lunar month, where only positive crescent conditions are astronomically relevant for rukyat observation. Negative crescent values where the Moon sets before or simultaneously with the Sun indicate conditions where rukyat is impossible and therefore fall outside the scope of this classification study.

a. Sabang City

The following is the crescent moon parameter data organized based on the Moon's longitude and perigee-apogee groups at sunset in Sabang City. This table presents information related to crescent moon lag, crescent moon age, crescent moon height, and crescent moon elongation for each Moon longitude range. Of the total 3,612 lunar phases calculated for Sabang City, 2,438 represent positive crescent visibility data (crescent above the horizon at sunset), which are presented in Table 1. The remaining 1,174 data points represent negative crescent values and are excluded from this classification table.

Table 1. Longitude Range Grouping in Sabang City

No	**Longitude Range Grouping**			**Total Data**	**Lag**		**Age**		**Height**		**Elongation**	
					Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
1	15	-	345	344	1.54	49.83	0.08	18.98	0.06	10.29	1.50	12.12
2	15	-	45	297	1.33	47.16	0.02	18.74	0.02	9.62	1.63	11.62
3	45	-	75	212	1.24	46.27	0.57	18.69	0.01	9.37	1.74	11.30
4	75	-	105	146	1.32	41.19	0.35	18.72	0.06	8.86	1.69	10.60
5	105	-	135	152	1.81	39.34	0.14	18.86	0.16	8.20	1.52	10.03
6	135	-	165	184	1.43	39.79	0.32	18.80	0.08	8.39	1.70	10.07
7	165	-	195	221	1.11	35.11	0.46	18.85	0.02	7.70	1.45	9.34
8	195	-	225	193	1.41	38.24	0.55	18.83	0.06	7.91	1.24	9.69
9	225	-	255	145	2.27	37.54	0.07	18.67	0.26	8.17	1.87	10.05

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[28] *Ibid.*

10	255	-	285	137	1.31	38.85	0.92	18.30	0.03	8.53	2.16	10.29
11	285	-	315	163	1.41	42.20	1.50	18.72	0.05	9.28	1.71	11.08
12	315	-	345	244	1.25	45.62	0.09	18.83	0.00	9.29	1.45	11.22

The distribution pattern of the maximum values for each parameter across longitude range groups is further illustrated in Figure 1. The Lag parameter shows the widest variation, with a declining trend from the 15°–345° group toward the 165°–195° longitude range, before rising again toward 315°–345°. Meanwhile, Height and Elongation show a slight downward trend toward the apogee range before rising again, while Age remains relatively stable across all longitude groups.

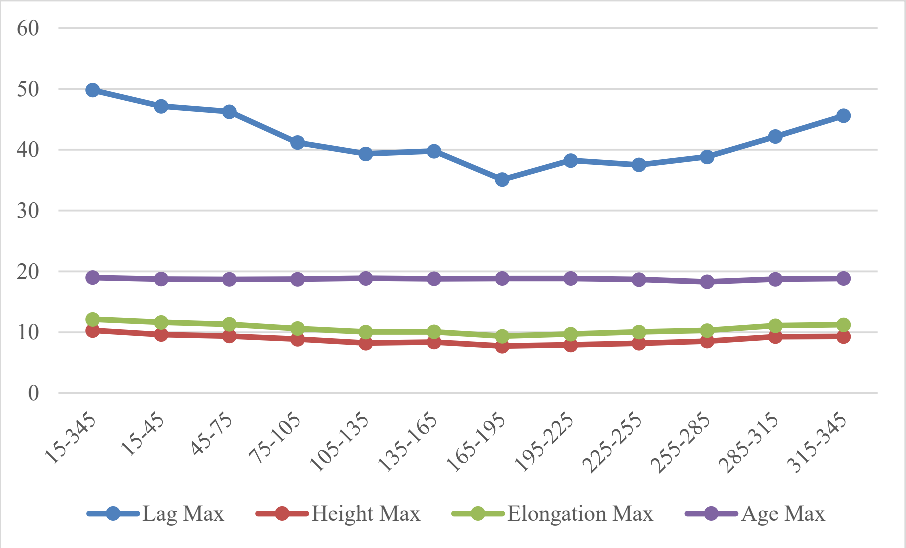

Figure 1. Maximum Crescent Moon Parameters by Longitude Range Group in Sabang City.

Based on Table 1, the grouping of total crescent sightings over 300 years across 12 orbital longitude ranges in Sabang City shows that the group with the highest frequency of data is significantly the longitude range 15°–345° which is the perigee longitude with the highest frequency (344 occurrences), followed by the range 315°–345° (244 occurrences), and the range 165°–195°, which is related to the apogee (221 occurrences). The lowest frequency was recorded in the longitude range 255°−285° (137 data points). The time parameter showed extreme values. The crescent lag ranged from a minimum of 1.11 minutes (recorded in the apogee range 165°−195°) to a maximum of 49.83 minutes (in the total perigee range 15°−345°). Similarly, the age of the crescent moon (Age) has a wide range, from a minimum of 0.02 hours (at a range of 15°−45° and 165°−195°) to a maximum of 18.98 hours (at a total perigee range of 15°−345°).

The data pattern is also reflected in visibility parameters such as the crescent height value, which ranges from 0.00° to 10.29°. The minimum height of 0.00° is recorded at a longitude range of 315°−345°. Overall, the maximum crescent height of 10.29° occurs at the total perigee range (15°−345°). Meanwhile, the elongation of the crescent moon ranges from 1.24° to 12.12°. The maximum elongation value of 12.12° is recorded at the total perigee range (15°−345°). The longitude range 165°−195° (apogee longitude) shows the tightest data range, recording lower maximum values for crescent height (7.70°) and crescent elongation (9.34°), while also recording the lowest minimum crescent lag among all longitude ranges.

b. Surabaya City

The following is data on crescent parameters compiled based on longitude groups and the Moon's perigee-apogee at sunset in the city of Surabaya. This table presents data on crescent lag, crescent age, crescent altitude, and crescent elongation for each range of lunar longitude. Of the total 3,612 lunar phases calculated for Surabaya City, 2,257 data points reflect positive crescent visibility conditions and are presented in Table 2. The remaining 1,355 data points with negative crescent values are excluded from this classification table.

Table 2. Longitude Range Grouping in Surabaya

No	**Longitude Range Grouping**	**Total Data**	**Lag**		**Age**		**Height**		**Elongation**	
			Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
1	15 - 345	311	1.35	43.53	0.00	17.48	0.04	8.94	1.50	11.33
2	15 - 45	274	1.34	44.40	0.38	17.54	0.05	8.94	1.44	10.94
3	45 - 75	192	1.27	41.75	0.10	17.77	0.04	8.88	1.78	10.59
4	75 - 105	144	1.58	36.58	0.04	17.56	0.12	8.00	1.66	10.24
5	105 - 135	140	1.31	38.37	0.14	17.50	0.06	7.67	1.61	9.69
6	135 - 165	179	1.56	37.21	0.37	17.79	0.11	7.87	1.35	9.52
7	165 - 195	201	1.20	33.01	0.02	17.41	0.03	7.21	1.42	8.93
8	195 - 225	179	1.33	36.24	0.33	17.65	0.06	7.50	1.27	9.20
9	225 - 255	137	1.44	37.36	0.85	17.41	0.06	7.93	1.47	9.62
10	255 - 285	122	1.33	37.20	0.08	17.34	0.03	7.72	1.65	9.77
11	285 - 315	151	1.24	40.71	0.30	17.28	0.01	8.66	1.91	10.39
12	315 - 345	227	1.38	42.67	0.24	17.49	0.05	8.76	1.73	10.71

The distribution pattern of the maximum values for each parameter across longitude range groups in Surabaya City is further illustrated in Figure 2. The Lag parameter exhibits the widest variation, with a declining trend from the 15°–345° group toward the 165°–195° longitude range, before gradually recovering toward 315°–345°. Meanwhile, Height and Elongation show a slight downward trend toward the apogee range before rising again, while Age remains relatively stable across all longitude groups.

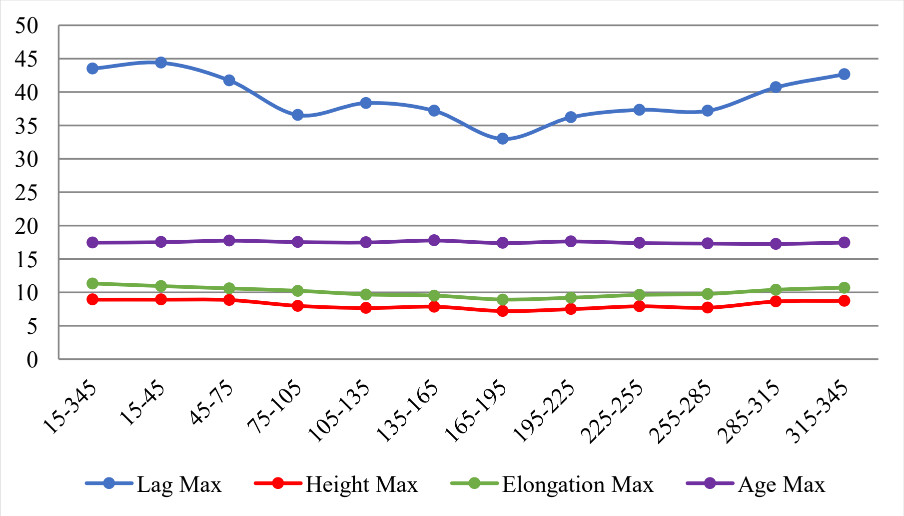

Figure 2. Maximum Crescent Moon Parameters by Longitude Range Group in Surabaya City.

Based on Table 2, the grouping of total crescent sightings over 300 years across 12 orbital longitude ranges in Surabaya City shows that the group with the highest frequency of data is significantly the longitude range 15°–345°, which is the perigee longitude with the highest frequency (311 occurrences), followed by the range 165°–195°, which is related to the apogee (201 occurrences). Conversely, the lowest frequency was recorded in the longitude range 255°−285° (122 data points), which is in the middle phase of the orbit. The crescent visibility parameter shows that the crescent lag varies from a minimum of 1.20 minutes (recorded at the apogee range 165°−195°) to a maximum of 44.40 minutes (at the range 15°−45°). Similarly, the age of the crescent moon (Age) has a wide range, from a minimum of 0.00 hours (at a perigee range of 15°−345°) to a maximum of 17.79 hours (at a range of 135°−165°).

The data pattern is also visible in visibility parameters, such as the high crescent value ranging from 0.01° to 8.94°. The minimum height is close to 0.01°, recorded at a longitude range of 285°−315°, while the absolute minimum value (height 0.00°) only occurs at the total perigee longitude range (15°−345°). The maximum crescent height value of 8.94° occurs in the perigee longitude range (15°−345°) and the range 15°−45°. Meanwhile, the crescent elongation ranges from 1.27° to 11.33°. The maximum elongation value of 11.33° is recorded in the total perigee range (15°−345°). The longitude range 165°−195° (apogee longitude) produces tight extreme values for the crescent height (7.21°) and crescent elongation (8.93°), indicating that the apogee position generally produces lower maximum visibility values than the perigee position.

c. Merauke City

The following is data on crescent parameters compiled based on the Moon's longitude and perigee-apogee groups at sunset in Merauke City. This table presents data on crescent lag, crescent age, crescent altitude, and crescent elongation for each range of the Moon's longitude. Of the total 3,612 lunar phases calculated for Merauke City, 2,281 data points reflect positive crescent visibility conditions and are presented in Table 3. The remaining 1,331 data points with negative crescent values are excluded from this classification table.

Table 3. Longitude Range Grouping in Merauke City

No	Longitude Range Grouping			Total Data	Lag		Age		Height		Elongation	
					Min	Max	Min	Max	Min	Max	Min	Max
1	15	-	345	313	1.34	47.03	0.28	17.95	0.02	9.43	1.96	11.42
2	15	-	45	289	1.37	49.06	0.22	17.90	0.05	9.75	1.47	11.72
3	45	-	75	188	1.20	43.16	0.42	17.77	0.02	8.62	1.69	10.71
4	75	-	105	144	1.17	41.85	1.31	17.97	0.01	8.20	1.58	10.14
5	105	-	135	144	1.19	39.49	0.55	17.87	0.03	8.06	1.42	9.92
6	135	-	165	162	2.04	35.27	1.29	17.46	0.24	7.65	1.71	9.36
7	165	-	195	200	1.65	36.30	0.34	17.85	0.13	7.38	1.81	9.29
8	195	-	225	179	1.06	37.82	0.51	17.74	0.01	8.15	1.25	9.79
9	225	-	255	145	1.08	40.33	0.33	17.98	0.00	8.12	1.45	9.92
10	255	-	285	127	1.11	41.52	0.29	17.99	0.00	8.52	1.52	10.25
11	285	-	315	160	1.38	40.89	0.20	17.98	0.02	8.02	1.40	10.21
12	315	-	345	230	1.47	43.88	0.21	17.90	0.05	9.31	1.38	11.22

The distribution pattern of the maximum values for each parameter across longitude range groups in Merauke City is further illustrated in Figure 3. The Lag parameter exhibits the widest variation, with a declining trend from the 15°–45° group toward the 135°–165° longitude range, before gradually recovering toward 315°–345°. Similarly, Height and Elongation display a consistent downward trend toward the apogee range before rising again, while Age remains relatively stable across all longitude groups.

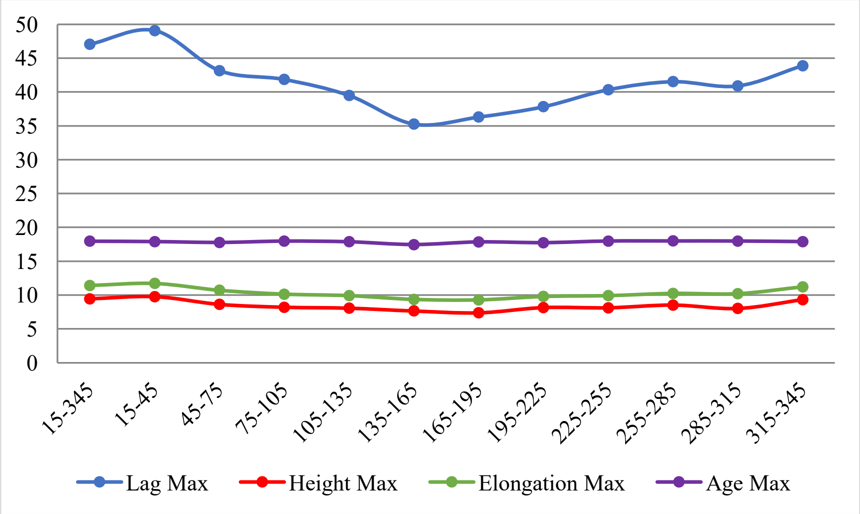

Figure 3. Maximum Crescent Moon Parameters by Longitude Range Group in Merauke City.

Based on Table 3, the total number of lunar perigee and apogee events over 300 years grouped into 12 orbital longitude ranges in Merauke City shows that the group with the highest frequency of data is significantly the longitude range 15°−345°, which represents the perigee longitude (313 events), followed by the range 165°−195°, which represents the apogee longitude (200 events). Meanwhile, the longitude range 255°−285° representing the middle phase of the orbit recorded the fewest number of events, namely 127 data points. Analysis of time parameters shows extreme values. The crescent lag varies from a minimum of 1.06 minutes (recorded in the range 195°−225°) to a maximum of 49.06 minutes (in the range 15°−45°). Similarly, the age of the crescent moon (Age) ranges from a minimum of 0.20 hours (in the range of 285°−315°) to a maximum of 17.99 hours (in the range of 255°−285°).

Further data presentation shows the range of values for visibility parameters, such as the high value of the crescent moon, which is in the range of 0.00° to 9.75°, where the minimum height of 0.00° is recorded in the longitude range of 225°−285° ((covering longitudes 240° and 270°). The maximum crescent height of 9.75° occurs within the longitude range of 15°−45°. Meanwhile, the crescent elongation ranges from 1.25° to 11.72°. The maximum elongation value of 11.72° was recorded in the longitude range of 15°−45°. In general, the longitude range of 165°−195° (apogee longitude) consistently displayed the most stringent data pattern, resulting in minimum extreme values for crescent height (0.13°) and crescent elongation (1.81°).

3. Analysis of Perigee and Apogee Longitude on Crescent Visibility Parameters Based on the New MABIMS Criteria

This study analyzes crescent visibility data and the longitude distance of the Moon from the perigee longitude at sunset after conjunction (Moon age > 0) from 1300H to 1600H (November 11, 1882 – October 26, 2174) in three locations: Sabang City, Surabaya City, and Merauke City. The classification data of the Apogee and Perigee longitudes against the crescent visibility parameters are then presented in tabular form. This analysis aims to measure the influence of the two calculation criteria, namely New MABIMS and Odeh, on changes in the perigee and apogee longitudes. The classification details the total number of data that meet (Meet Criteria/MK) and do not meet (Do Not Meet Criteria/TMK) the visibility threshold. For the apogee and perigee groups based on the New MABIS criteria calculated from the cities of Sabang, Surabaya, and Merauke, the results can be summarized and simplified in the table below:

Table 4. Apogee and Perigee Distribution Data Based on New MABIMS Criteria in Sabang, Surabaya, and Merauke[29]

	Sabang	**Surabaya**	**Merauke**	**Total Data**
New Mabims - Apogee / Perigee				
Apogee and Visible Groups According to MABIMS				

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[29] The "Meets Criteria" and "Does Not Meet Criteria" rows represent the total of all lunar phases across the complete 300-year dataset (3,612 data points per city), not limited to apogee and perigee classifications only. In Sabang, 1,508 data points meet the New MABIMS criteria; in Surabaya, 1,516; and in Merauke, 1,515. The apogee and perigee groups are sub-classifications within the complete dataset reflecting the distribution of visibility outcomes across orbital positions.

Apogee and Visible (A MK)	481	410	423	1314
Apogee and Not Visible (A TMK)	827	894	887	2608
Perigee and Visible Group According to MABIMS				
Perigee and Visible (P MK)	62	52	49	163
Perigee and Not Visible (P TMK)	146	152	156	454
Data that Meets Criteria and Does Not Meet Criteria				
Meets Criteria	1516	1508	1515	4539
Does Not Meet Criteria	2096	2104	2097	6297
Total Data	3612	3612	3612	10836

Meanwhile, for the apogee or perigee groups based on Odeh's criteria calculated from the cities of Sabang, Surabaya, and Merauke, the results can be summarized and simplified in the table below:

Table 5. Apogee and Perigee Distribution Data Based on Odeh's Criteria in the Cities of Sabang, Surabaya, and Merauke[30]

Odeh - Apogee / Perigee	**Sabang**	**Surabaya**	**Merauke**
Apogee and Visible Groups According to Odeh			
Apogee and Visible Kriteria A (A MK)	2	0	0
Apogee and Visible Kriteria B (A MK)	176	117	119
Apogee and Visible Kriteria C (A MK)	228	222	249
Apogee and Visible According to Odeh	406	339	368
Apogee and Non-Visible Groups According to Odeh			
Apogee and Not Visible (A TMK)	902	965	942
Perigee and Visible Group According to Odeh			
Perigee and Visible Kriteria A (P MK)	0	0	0
Perigee and Visible Kriteria B (P MK)	10	5	5
Perigee and Visible Kriteria C (P MK)	41	36	30
Perigee and Visibility According to Odeh	51	41	35
Perigee and Not Visible Groups According to Odeh			
Perigee and Not Visible (P TMK)	157	163	170
Data that Meets Criteria and Does Not Meet Criteria			
Meets Criteria	863	719	771
Not Meeting Criteria	2096	2104	2097
Total Data	3612	3612	3612

Based on the data from the visibility calculations of the crescent moon conducted in three Indonesian cities (Sabang, Surabaya, and Merauke) during the period from 1300H to 1600H

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[30] The "Meets Criteria" and "Does Not Meet Criteria" rows represent the total of all lunar phases across the complete 300-year dataset (3,612 data points per city), not limited to apogee and perigee classifications only. In Sabang, 863 data points meet the Odeh criteria; in Surabaya, 719; and in Merauke, 771. The apogee and perigee groups are sub-classifications within the complete dataset reflecting the distribution of visibility outcomes across orbital positions based on Odeh's criteria.

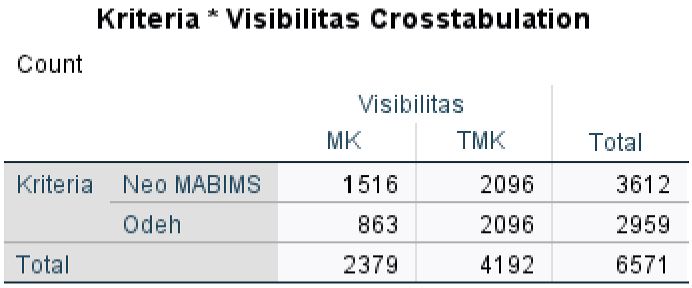
(November 11, 1882 – October 26, 2174), there are several significant findings that can be analyzed in depth. This analysis covers 3,612 lunar data from each city, focusing on three main aspects, namely the comparison of the apogee-perigee phenomenon, differences in observation criteria, and the influence of geographical factors.

The comparison between the apogee and perigee phenomena shows that the apogee phenomenon consistently has a higher success rate than the perigee at all observation locations. This can be explained by several factors: First, at the apogee position, the Moon moves more slowly because it is at its furthest point from Earth, providing longer observation time and more stable conditions for observation. Quantitative data supports this, where according to New MABIMS criteria, the apogee phenomenon achieves a 11-13% success rate, while the perigee only achieves 1-2%. Numerically, this difference is very significant. In the city of Sabang, for example, there were 481 apogee data points that met the New MABIMS criteria, while there were only 62 perigee data points. A similar pattern was also seen in Surabaya, with 410 apogee data points compared to 52 perigee data points, and in Merauke, with 423 apogee data points compared to 49 perigee data points.

In terms of observation criteria comparison, the analysis revealed that the New MABIMS criteria consistently provided higher visibility results than the Odeh criteria. This difference was mainly due to different measurement methodologies and parameters. The New MABIMS criteria use a simpler approach with only two categories (visible and invisible), while the Odeh criteria have more specific parameters in the observation method, namely with the naked eye, optical instruments, or a combination of both. This difference is reflected in the amount of data that meets the criteria in each city. In Sabang, 1,516 data points met the New MABIMS criteria compared to 863 data points for the Odeh criteria. A similar pattern was seen in Surabaya, where 1,508 data points met the New MABIMS criteria compared to 719 for the Odeh criteria, and in Merauke, where 1,515 data points met the New MABIMS criteria compared to 771 for the Odeh criteria. This significant difference indicates that the Odeh criteria apply stricter and more specific standards in determining the visibility of the crescent moon.

To statistically confirm the difference in visibility outcomes between the New MABIMS and Odeh criteria, a chi-square test of independence was conducted for each city. The following tables present the crosstabulation and chi-square test results for Sabang, Surabaya, and Merauke, respectively:

Table 6. Crosstabulation of Crescent Visibility Criteria in Sabang City



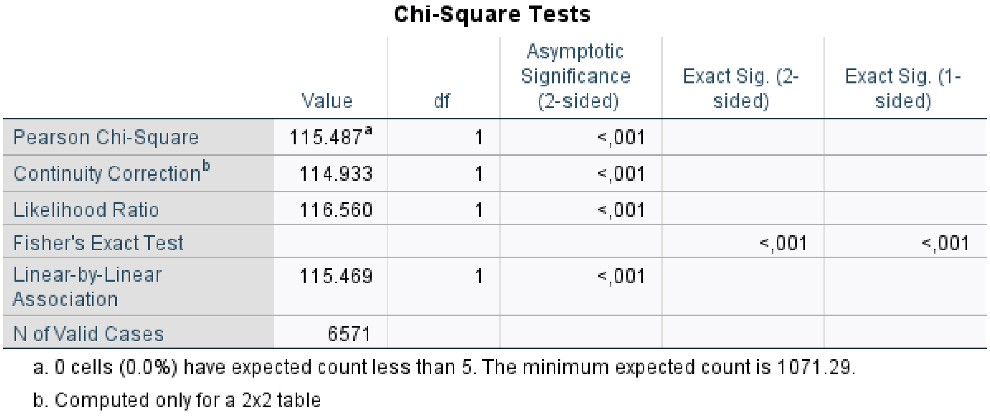
Kriteria * Visibilitas Crosstabulation

Count

		Visibilitas		
		MK	TMK	Total
Kriteria	Neo MABIMS	1516	2096	3612
	Odeh	863	2096	2959
Total		2379	4192	6571

Based on the crosstabulation of crescent visibility criteria in Sabang City, the same dataset of 3,612 observations was analyzed using two different criteria, resulting in a total of 6,571 cases in the crosstabulation table. Under the New MABIMS criteria, 1,516 observations met the visibility threshold (MK) and 2,096 did not (TMK). Under the Odeh criteria, 863 observations met the threshold (MK) while 2,096 did not (TMK). The overall total indicates 2,379 cases meeting the criteria and 4,192 cases not meeting the criteria. These figures suggest that non-visible crescent occurrences are more dominant than visible ones under both criteria, with New MABIMS yielding a higher number of MK cases compared to Odeh.

Table 7. Chi-Square Test Results in Sabang City



Chi-Square Tests

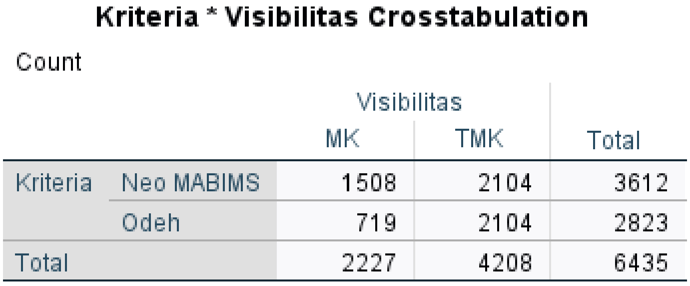
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	115.487[a]	1	<,001		
Continuity Correction[b]	114.933	1	<,001		
Likelihood Ratio	116.560	1	<,001		
Fisher's Exact Test				<,001	<,001
Linear-by-Linear Association	115.469	1	<,001		
N of Valid Cases	6571				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 1071.29.

b. Computed only for a 2x2 table

The chi-square test yielded a Pearson Chi-Square value of 115.487 (df=1, p<0.001). Based on the decision rule that a significance value below 0.05 indicates a statistically significant difference between the compared criteria, and a value above 0.05 indicates no significant difference, it can be concluded that there is a significant difference between the New MABIMS and Odeh criteria in determining crescent visibility in Sabang City.

Table 8. Crosstabulation of Crescent Visibility Criteria in Surabaya City



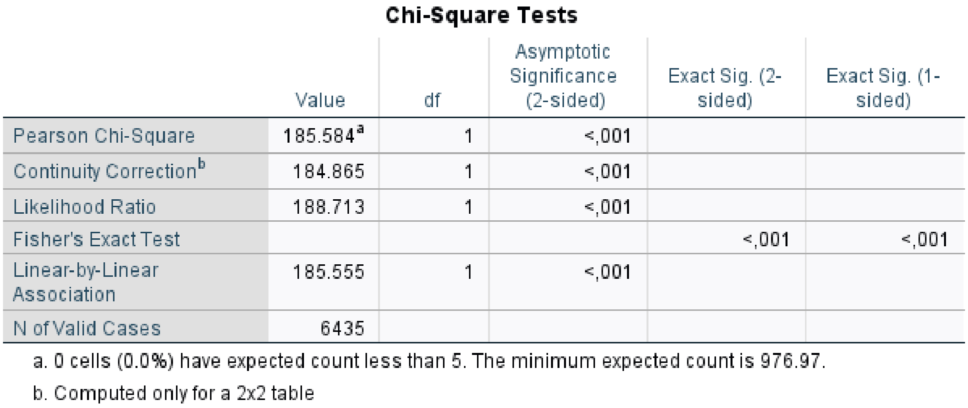
Kriteria * Visibilitas Crosstabulation

Count

		Visibilitas		
		MK	TMK	Total
Kriteria	Neo MABIMS	1508	2104	3612
	Odeh	719	2104	2823
Total		2227	4208	6435

Based on the crosstabulation of crescent visibility criteria in Surabaya City, the same dataset of 3,612 observations was analyzed using two different criteria, resulting in a total of 6,435 cases in the crosstabulation table. Under the New MABIMS criteria, 1,508 observations met the visibility threshold (MK) and 2,104 did not (TMK). Under the Odeh criteria, 719 observations met the threshold (MK) while 2,104 did not (TMK). The overall total indicates 2,227 cases meeting the criteria and 4,208 cases not meeting the criteria. These figures suggest that non-visible crescent occurrences are more dominant than visible ones under both criteria, with New MABIMS yielding a considerably higher number of MK cases compared to Odeh.

Table 9. Chi-Square Test Results in Surabaya City



Chi-Square Tests

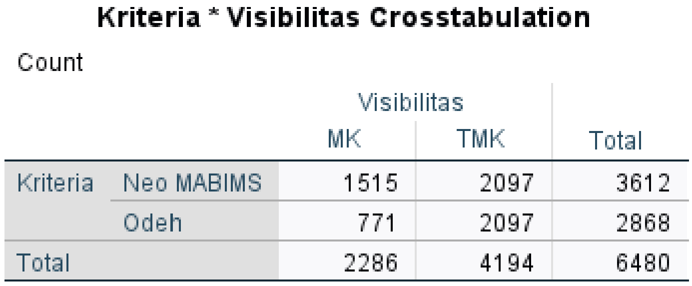
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	185.584[a]	1	<,001		
Continuity Correction[b]	184.865	1	<,001		
Likelihood Ratio	188.713	1	<,001		
Fisher's Exact Test				<,001	<,001
Linear-by-Linear Association	185.555	1	<,001		
N of Valid Cases	6435				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 976.97.

b. Computed only for a 2x2 table

The chi-square test yielded a Pearson Chi-Square value of 185.584 (df=1, p<0.001). Based on the decision rule that a significance value below 0.05 indicates a statistically significant difference between the compared criteria, and a value above 0.05 indicates no significant difference, it can be concluded that there is a significant difference between the New MABIMS and Odeh criteria in determining crescent visibility in Surabaya City.

Table 10. Crosstabulation of Crescent Visibility Criteria in Merauke City



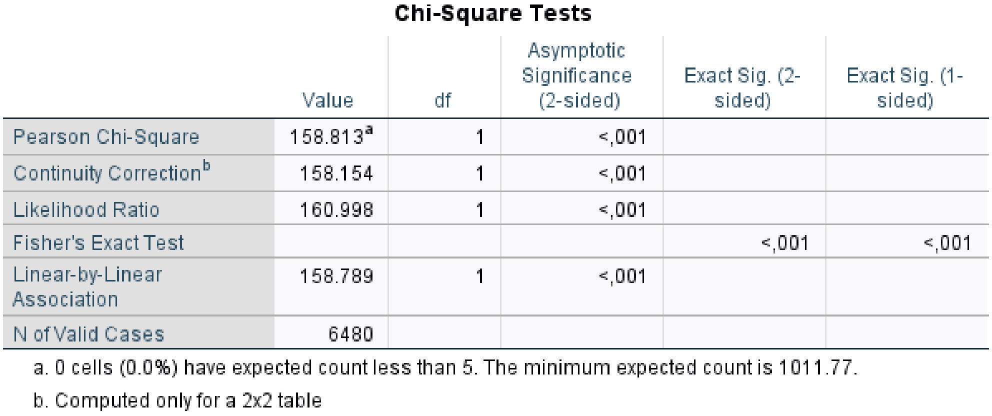
Kriteria * Visibilitas Crosstabulation

Count

		Visibilitas		
		MK	TMK	Total
Kriteria	Neo MABIMS	1515	2097	3612
	Odeh	771	2097	2868
Total		2286	4194	6480

Based on the crosstabulation of crescent visibility criteria in Merauke City, the same dataset of 3,612 observations was analyzed using two different criteria, resulting in a total of 6,480 cases in the crosstabulation table. Under the New MABIMS criteria, 1,515 observations met the visibility threshold (MK) and 2,097 did not (TMK). Under the Odeh criteria, 771 observations met the threshold (MK) while 2,097 did not (TMK). The overall total indicates 2,286 cases meeting the criteria and 4,194 cases not meeting the criteria. These figures suggest that non-visible crescent occurrences are more dominant than visible ones under both criteria, with New MABIMS yielding a higher number of MK cases compared to Odeh.

Table 11. Chi-Square Test Results in Surabaya City



Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	158.813[a]	1	<,001		
Continuity Correction[b]	158.154	1	<,001		
Likelihood Ratio	160.998	1	<,001		
Fisher's Exact Test				<,001	<,001
Linear-by-Linear Association	158.789	1	<,001		
N of Valid Cases	6480				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 1011.77.

b. Computed only for a 2x2 table

The chi-square test yielded a Pearson Chi-Square value of 158.813 (df=1, p<0.001). Based on the decision rule that a significance value below 0.05 indicates a statistically significant difference between the compared criteria, and a value above 0.05 indicates no significant difference, it can be concluded that there is a significant difference between the New MABIMS and Odeh criteria in determining crescent visibility in Merauke City.

Discussion

This study analyzes the classification between the Moon's perigee-apogee longitude and crescent visibility during the 1300H-1600H period in three Indonesian cities using the New MABIMS and Odeh criteria. Analysis of 10,836 lunar data points found that the apogee phenomenon consistently showed higher visibility levels than the perigee at all observation locations. Quantitatively, the New MABIMS criteria recorded an apogee success rate of 11-13%, while perigee only achieved 1-2%. Data distribution shows that in Sabang there were 481 apogees compared to 62 perigees, in Surabaya 410 compared to 52, and in Merauke 423 compared to 49. A comparison of observation criteria reveals that New MABIMS provides higher visibility results (Sabang 1,516, Surabaya 1,508, Merauke 1,515) than Odeh (Sabang 863, Surabaya 719, Merauke 771). This is due to differences in methodology: New MABIMS uses two simple categories (visible/not visible), while Odeh applies specific parameters based on observation methods, classifying visible cases into three sub-categories: visible to the naked eye (Criteria A), visible with optical aid under ideal sky conditions (Criteria B), and visible with optical aid only (Criteria C). In this study, all three Odeh sub-categories are counted as visible to allow comparison with the binary New MABIMS classification. Despite this inclusive counting approach, the total visible cases under Odeh remain considerably lower than under New MABIMS, reflecting the more stringent and specific nature of the Odeh criteria. A further breakdown of the Odeh visibility sub-categories reveals that of the 1,113 total apogee visible cases, only 2 cases were visible to the naked eye (Criteria A), 412 cases were visible with optical aid under ideal sky conditions (Criteria B), and 699 cases were visible with optical aid only (Criteria C). For the perigee group, none of the 127 visible cases were observable with the naked eye, with 20 cases falling under Criteria B and 107 under Criteria C. These figures indicate that under the Odeh criteria, crescent visibility in Indonesia is predominantly dependent on optical instruments, with naked-eye observation being exceptionally rare. This further explains the substantial difference between Neo MABIMS and Odeh visible case totals, as Neo MABIMS does not impose instrument-based sub-classifications in its visibility threshold.

The statistical analysis further supports this finding. A chi-square test of independence was conducted to confirm whether the difference in visibility outcomes between the two criteria is statistically significant. Based on the decision rule that a significance value below 0.05 indicates a statistically significant difference, the results obtained for all three cities (Sabang: $p<0.001$; Surabaya: $p<0.001$; Merauke: $p<0.001$) confirm that the disparity in crescent visibility determination between New MABIMS and Odeh criteria is statistically significant. This reinforces the conclusion that the choice of observation criteria fundamentally affects visibility outcomes, with New MABIMS systematically producing higher visibility rates due to its less restrictive threshold compared to the more stringent Odeh criteria.

Regarding the influence of geographical factors, although Sabang, Surabaya, and Merauke have different geographical characteristics, the variation in observation results is relatively small. It should be noted that these three cities are still located around the equator, with latitude coordinates within the general latitude range in Indonesia, which is between 6° N – 11° S. Sabang 5°53' N showed the best observation results, followed by Surabaya 7°15' S, and Merauke 8°29' S. The variation in latitude between these three cities is not very significant, which results in relatively similar geographical conditions for crescent moon observation. Sabang recorded the highest visibility data among the three cities, although the margin is marginal. This result cannot be attributed solely to its Northern Latitude position, as visibility is also significantly influenced by the declination of the Sun and Moon at the time of observation. Southern latitude locations such as Merauke may occasionally yield more favorable conditions during periods of strongly negative declination. Therefore, the variation in observation results across the three cities reflects a combination of latitudinal and seasonal astronomical factors rather than latitude alone.

The high frequency of crescent visibility at the apogee position is caused by differences in the angular velocity of the Moon in its orbit. Based on Kepler's Second Law,[31] when the Moon is at apogee (the farthest point, averaging 405,696 km), its speed slows down, resulting in a longer lag time between sunset and moonset, which directly increases the chances of observing the crescent moon. Conversely, at perigee (closest point, average 363,104 km), the Moon moves faster, making observation more difficult. Although maximum parameters such as crescent height (10°29'and elongation at the perigee position show higher values, these conditions occur for a very short duration due to high orbital velocity, causing highly fluctuating lag times (1.54-49.83 minutes). In contrast, the apogee longitude range (165°-195°) consistently shows a tight data pattern with a more stable minimum lag time (1.11 1.65 minutes), providing better observation opportunities despite a lower maximum crescent height (7°21'-7°70').

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[31] Heri Kiswanto, *Fisika Dasar 1* (Syiah Kuala Univerity Press, 2021), 133.

These findings show that the apogee has a higher visibility frequency than the perigee, supported by descriptive patterns and statistically confirmed through a chi-square test of independence. This difference in frequency is related to the stability of observations when the Moon moves more slowly at the apogee, though further empirical validation is needed for comprehensive confirmation. This is in line with Prof. Thomas Djamaluddin's view on the need for visibility criteria that are open to refinement through scientific data.[32] Based on the limitations of the findings, further research is needed with a focus on empirical validation through actual observations before using perigee-apogee as a prediction factor. Research that integrates orbital parameters with atmospheric conditions can provide a more comprehensive understanding. Thus, this study provides an initial overview that requires further verification to support the accuracy of crescent visibility predictions in Indonesia.

D. Conclusion

This study analyzes the classification pattern of the Moon's perigee-apogee longitude position in relation to the visibility level of the crescent moon during the 1300H-1600H period in Indonesia. Analysis of 10,836 data points from Sabang, Surabaya, and Merauke shows that the crescent moon at the apogee position has a higher visibility frequency than the perigee position under both criteria. Based on the New MABIMS criteria, apogee recorded 1,314 visible cases compared to 163 perigee cases, while the Odeh criteria recorded 1,113 apogee cases compared to 127 perigee cases. A comparison of the criteria shows that New MABIMS produced more visible data (4,539 cases) than Odeh (2,353 cases) due to differences in methodology. New MABIMS uses two simple categories (visible/invisible), while Odeh applies more specific parameters based on observation methods (naked eye, optical instruments, or a combination). A chi-square test of independence further confirmed that this difference is statistically significant across all three cities ($p<0.001$), with New MABIMS consistently yielding higher visibility rates than the more stringent Odeh criteria.

The observed difference in visibility frequency is related to the Moon's angular velocity slowing down at apogee, resulting in longer observation durations and more stable conditions. The data distribution pattern is relatively consistent across the three locations with minor geographical variations, indicating that orbital factors play a more dominant role than geographical factors in determining crescent visibility in the Indonesian equatorial region.

The main limitation of this study is that it is a theoretical data-based analysis without field observation validation and does not integrate atmospheric factors such as weather, humidity, and light pollution, which in practice determine the success of crescent observation. Further research is needed for empirical validation through comparison of predictions with actual rukyat data, as well as integration of orbital parameters with local atmospheric conditions to produce a more comprehensive understanding of the factors that influence crescent visibility in Indonesia.

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[32] Akhmad Syaikhu, "Pemikiran Thomas Djamaluddin Tentang Unifikasi Kalender Islam Di Indonesia" (Tesis, Institut Agama Islam Negeri Antasari, 2015), 217.

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