Assessment of Light Pollution at New Crescent Moon Observation Sites in Terengganu, Malaysia: A Multi Brightness Metric Approach

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Assessment of Light Pollution at New Crescent Moon Observation Sites in Terengganu, Malaysia: A Multi Brightness Metric Approach

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Abstract: *This study evaluated light pollution in four areas in Terengganu, Malaysia, namely Bukit Geliga, Pulau Perhentian, KUSZA Observatory and Bukit Besar. Measurements involved using a multi-brightness metric approach for determining sky brightness (SQM), Luminance (cd/m²), Bortle scale and nude-eye limiting magnitude (NELM), and each measurement was compared with the predicted values. Results indicated that Pulau Perhentian and KUSZA Observatory had darker skies with SQM values of 20.9 and 21.33 mag/arcsec², NELM values of 6.06 and 6.3, and low luminance of* $4.714x10^{-4}$ *and* $3.24x10^{-5}$ *cd/m², respectively, thereby making them suitable for the sighting of new crescent moons. In contrast, Bukit Geliga and Bukit Besar had brighter skies with lower SQM values of 18.5 and 18.15 mag/arcsec², lower NELM readings of 4.38 and 4.09, and higher luminance levels of* $4.300x10^{-3}$ *and* $5.935x10^{-3}$ *cd/m², respectively. Correlation verifications revealed strong relationships between all metrics, thus, proving that darker skies lead to improved visibility. Overall, Pulau Perhentian and KUSZA Observatory had the darkest skies, with SQM values of 20.9 and 21.33, and low luminance of* 4.714×10^{-4} *and* 3.173×10^{-4} *cd/m², respectively, confirming their suitability for new crescent moon observations. This study's findings can help Jabatan Mufti Negeri Terengganu to better understand actual sky conditions and visibility potential at the existing regional sites, while assisting in selecting more appropriate sites for future new crescent moon observations.*

***Keywords*:** Light Pollution, Sky Quality Meter, Sky Brightness, New Crescent Moon Observation Site, Multi-Brightness Metrics.

1. INTRODUCTION

The acceleration of artificial light at night, or ALAN, has become one of the most prominent sources of pollution around the globe, and this strongly impacts ecological systems, damages human health and hinders astronomical observations [1][2]. The astronomical community's primary concern is the deterioration of night sky quality due to over-lighting. Sky brightness during observatory operations, particularly at the zenith, serves as an important benchmark for optical transparency assessment and evaluating the performance of ground-based observatories. ALAN lighting modifies the night sky's natural brightness and creates a new illuminating phenomenon known as skyglow, which profoundly affects the concealment of faint space objects [3][4].

The problem of light pollution involves scientists all over the world as it disrupts natural ecosystems and astronomical observations. Several primary research institutions, such as the Palomar Observatory in California and some Chilean observatories, are increasingly hindered by urban sprawl and artificial lighting [1]. The cycle-turning invention of the electric light bulb by Thomas Edison in 1879 marked the beginning of light pollution and the degradation of the night sky from the scattering of artificial light in the atmosphere [3]. Optical observatories began feeling the impact of light pollution as early as 1972, lending them little hope for future advancements in their field [2]. In more recent years, researchers at the Bosscha Observatory in Indonesia demonstrated that skyglow diminished environmental quality and interfered with astronomical observations of the night sky [4]. Such findings reaffirm the necessity for regulating emissions of artificial light to curb light-sky pollution for ecological and scientific reasons.

The past two decades has seen Malaysia being transformed by intensifying semi-rural and urban artificial lighting. While faint progress, from a public perspective, has been made through individual initiatives by groups like Dark Sky Malaysia, scientific efforts related to ALAN research in Malaysia continues to be patchy, poorly coordinated and overly reliant on a standardized framework adopted from other observatories. Even more neglected are the new crescent moon also called young crescent moon observation sites, locally known as *rukyah hilal* stations, which hold scientific significance and play an important role in determining the Islamic calendar used for deciding the commencement of religiously significant months like Ramadan, Syawal and Zulkaedah [5][6]. The accuracy required for making these religious-based observations is extremely dependent on the level of atmospheric clarity and light pollution present, most critically during dusk when the delicate crescent is likely to be visible.

As this study discovered, systematic *hilal* observations in Malaysia have not incorporated quantitative light pollution measures. Even worse, the bias criteria for stationary bound fleet usage seems to stem from a combination of effortless accessibility and historical preference. This is particularly concerning given the growing number of reports of failed or contested sightings of certain phases of the moon, many of which could likely be the result of increasingly poor sky conditions caused by uncontrolled light emissions. In the absence of scientific rationale regarding site selection or control measures, the accuracy and reliability of astronomical and religious-based observations would be continuously undermined.

Like other new crescent moon observation sites in Malaysia, the Bukit Geliga site is no exception since it has been designated as the 29th observatory in the country. There are a few possible situational problems with New Crescent Moon sightings that can make visibility detection difficult at this site. While visiting the study site and collecting data it was found that the possibility of high levels of light pollution during New Crescent Moon sightings at this particular location is very slim and difficult to encounter. Such enduring circumstances continue to challenge the significance of the site and determine the possibility of sighting the New Crescent Moon, especially in Terengganu. This study aimed to address this matter by making a preliminary scientific study on sky brightness in Bukit Geliga and three other official New Cresent Moon observation sites in the state, namely Pulau Perhentian, Kolej Ugama Sultan Zainal Abidin (KUSZA) Observatory and Bukit Besar. It was anticipated that this study's findings will be useful for future studies on policies concerning site optimization and strategies, such as creating a data platform for light pollution in view of New Crescent Moon sightings in Malaysia.

In efforts to fill this gap, this study conducted a light pollution assessment involving multi-metric sky brightness measurements at four official *hilal* observation stations in Terengganu, Malaysia. These sites were chosen because of their participation in state and national crescent sighting activities. Standardized photometric instruments, such as the Sky Quality Meter (SQM), were used to capture zenithal sky brightness expressed in magnitudes per arcsecond squared (mag/arcsec²), as is customary when measuring the night sky's darkness [7][8]. Other measurements, such as luminance (cd/m²), Naked-Eye Limiting Magnitude (NELM) and Bortle Scale class, were used to obtain a comprehensive picture of ALAN's effect on these areas. This study evaluated and categorized the degree of light pollution surrounding these new crescent moon sighting stations using various criteria with the intention of providing evidence for state-level policymaking and observatory planning. It was envisaged that the results would resolve two fundamental questions, namely how severely has light pollution compromised visibility at the officially designated *rukyah hilal* sites in Terengganu and will the sites remain relevant for fulfilling astronomical and religious objectives in the absence of regulatory changes. This study addressed an important gap in the scholarship by providing sky brightness measurements, while integrating religious observances, notably in Malaysia. It will enable policymakers, religious officials and astronomers to act responsibly by implementing immediate measures aimed at protecting dark sky areas through lighting control policies, educational outreach and designated observation zone polemics.

2. METHODOLOGY

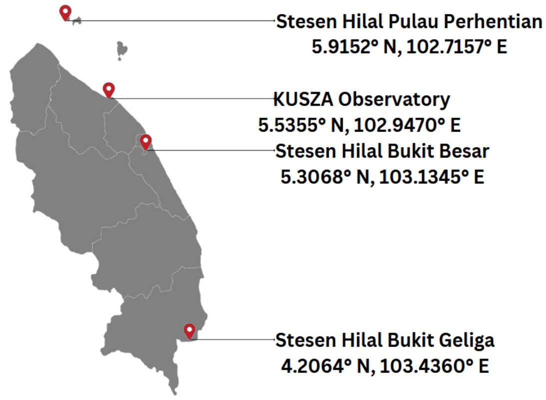


Fig. 1. Location of New Crescent Moon Observation Sites in Terengganu.

This study utilized the multi brightness metric method to evaluate night sky quality at four official new crescent moon (*hilal*) observation stations in Terengganu, Malaysia using field observation techniques. These stations were selected for their relevance to observations that determine the Islamic religious calendar and their strategic location on the eastern coastline of Peninsular Malaysia. This approach aimed to measure and categorize light pollution using several interconnected indices, including the sky's brightness (measured in mag/arcsec²), luminance (cd/m²), Bortle scale classification, and naked eye limiting magnitude (NELM).

The four sites chosen (see Figure 1) in this study were Bukit Geliga (4.2064° N, 103.4360° E) in Kemaman, Pulau Perhentian (5.9152° N, 102.7157° E) in Besut, KUSZA Observatory (5.5355° N, 102.9470° E) in Merang, Setiu and Bukit Besar in Kuala Terengganu (5.3068° N, 103.1345° E). These locations have been historically utilized for *hilal* observation and are located within a mix of coastal, semi-rural and peri-urban settings, which makes them ideal for assessing artificial light at night. In this study, observational data was collected from June 2024 to May 2025.

Observations were undertaken using the Sky Quality Meter - Lens USB Data Logging version (SQM-LU-DL) built by Unihedron. The device is noted for its precise and accurate measurement of zenithal sky brightness that is expressed in mag/arcsec² with greater values closer to full darkness. This model is equipped with an optical lens that casts a narrower view of the instrument and mitigates light pollution from sources on the horizon. The SQM-L has a limiting aperture diameter of 20° at full width and half maximum. Cinzano explained that this SQM model, with a FWHM of 20°, can better focus on a narrow region of the sky and provide better reliable readings from the zenith direction [9]. The meter was pointed vertically and mounted on a stable

tripod. Data were captured in three separate locations during moonless and clear nights with intrusive sources of light. Observation sessions were held for every specific location at predetermined days to stabilize light conditions. Continuous observation was performed for each location spanning 10 to 15 minutes to ensure consistent intervals and for capturing average conditions.
In order to interpret sky brightness in physical photometric terms, mag/arcsec² values were transformed into luminance using Garstang's 1986 formula [10]:

$$\text{Luminance (cd/m}^2\text{)} = 10.8 \times 10^4 \times 10^{(-0.4 \times \text{mag})}$$

This allows comparisons to be made across different domains and is particularly important for urban planning and light regulation in an environment. Each site was given a Bortle class classification for the overall qualitative sky quality, which is a secondary class in the Bortle classifications. These classes, delineated from standard magnitude thresholds range, from 1 and 9, with 1 being excellent dark skies and 9 being the inner-city sky [11]. These values enable the conversion of technical data into simpler language usable by amateur and professional astronomers.
Alongside the instrumental measurements conducted as part of this study, the Naked Eye Limiting Magnitude estimation, which is defined as *the faintest unassisted stellar magnitude observable given the right conditions*, was also carried out using Knoll's formula [12]:

$$\text{NELM} = 7.93 - 5 \log_{10}(4.316 - (\text{mag}/5)) + 1$$

This allows for an adaptation of measured data where the expected sky conditions at each location pose the greatest limitation on observation.
Comparisons were made between measured values of sky brightness and available satellite-based light pollution maps to evaluate the reliability of observations, including those from VIIRS and other public repositories. This step included the comparison of simulated and observed sky brightness values (mag/arcsec²), luminance (cd/m²), Bortle class and NELM. These assessments validated the field measurements against pre-existing benchmarks and sought to determine localized sources of divergence, such as novel light intrusion or alteration of structures [13][14].
Data analysis had used the Microsoft Excel software, while a moving average method was employed to reduce short-term variability in the readings and enhance data reliability. Correlation between computed and derived parameters were presented using bar charts and scatter plots. Furthermore, standard deviation for each parameter in all the sites was calculated to assess the measurements' reliability and detect anomalous values. This approach allows for an integrated evaluation of the sky's quality with respect to quantitative and qualitative aspects, thereby enabling an accurate assessment of light pollution at crescent observation sites in Terengganu [15][16].

3. RESULTS AND DISCUSSION

This section provides the light pollution level assessment results based on actual and expected light pollution at four official new crescent moon sighting sites in Terengganu, namely Bukit Geliga, Pulau Perhentian, KUSZA Observatory and Bukit Besar. Each of the four sites was analysed using multiple brightness metrics, including qualitative evaluation of the Bortle scale, total sky luminous intensity measured in candela per square meter, SQM readings (sky brightness in magnitude per square arcsecond), and NELM (the faintest star observable to the unaided eye). Results of the assessments performed at the four sites were compared against the predicted data in order to understand the function of each location during practical conditions and assess the suitability of each site for observing new crescent moon ingresses.

3.1 Comparison of Observed and Predicted Brightness Metrics

Table 1. The Sky Brightness's Value and Bortle Class at New Cresent Moon Observation Sites in Terengganu.\

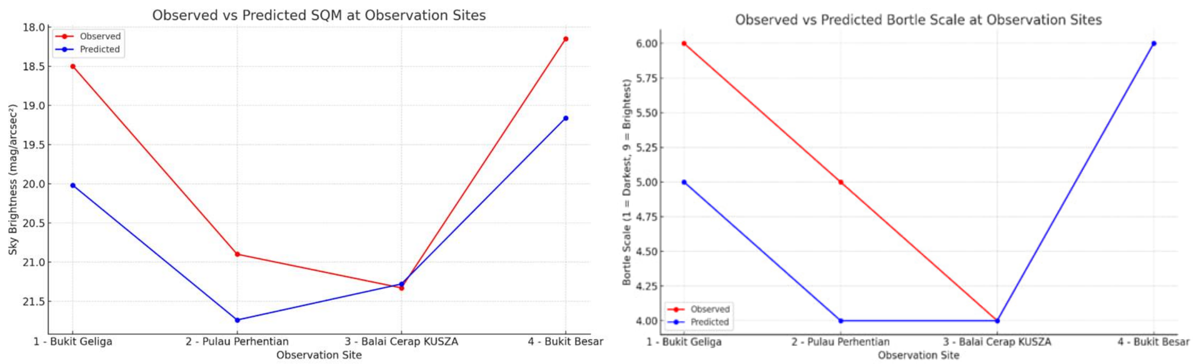
Location	SQM Observation (mag/arcsec²)	SQM Prediction (mag/arcsec²)	Bortle Scale Observation	Bortal Scale Prediction
1 - Bukit Geliga	18.5	20.02	6	5
2 - Pulau Perhentian	20.9	21.74	5	4
3 - KUSZA Observatory	21.33	21.28	4	4
4 - Bukit Besar	18.15	19.16	6	6

Table 2. The luminance value and NELM at New Cresent Moon Observation Sites in Terengganu

Location	Brightness (cd/m²) Observation	Brightness (cd/m²) Prediction	NELM Observation	NELM Prediction
1 - Bukit Geliga	4.300×10^{-3}	1.060×10^{-3}	4.38	5.51
2 - Pulau Perhentian	4.714×10^{-4}	2.175×10^{-4}	6.06	6.5
3 - KUSZA Observatory	3.173×10^{-4}	3.322×10^{-4}	6.3	6.27
4 - Bukit Besar	5.935×10^{-3}	2.341×10^{-3}	4.09	4.89

This study drew upon the magnitudes per arcsecond squared (mag/arcsec²) value to gauge the brightness of Sky Quality Meter (SQM), which is more pertinent for being a ratio instead of an absolute value in a given the domain since it is an astronomical unit of measurement. In order to streamline cross-disciplinary comprehension, these SQM readings were also converted to cd/m², a measurement of luminance that describes how bright the sky appears to the observer's eye in a given direction. As an observation rather than an illuminative design from a spatial perspective, the study focused exclusively on spatially bounding the problem to estimate the vertical illumination from the atmosphere downwards, hence the reason why luminance is a more fitting choice. Based on the findings shown in Table 1, the SQM values for Bukit Geliga and Bukit Besar suggest that the two locations had brighter skies than what was expected. As for Bukit Geliga, the sky brightness reading was 18.5 mag/arcsec² as opposed to the predicted reading of 20.02 mag/arcsec², whereas Bukit Besar recorded 18.15 mag/arcsec² instead of 19.16 mag/arcsec² as predicted. These differences indicate that both areas experienced greater artificial light pollution than what the simulation data had predicted. Conversely, Pulau Perhentian and Balai Cerap KUSZA had values of 20.9 mag/arcsec² and 21.33 mag/arcsec², respectively, which were close to the predicted values of 21.74 mag/arcsec² and 21.28 mag/arcsec², implying that these two sites are better positioned to enjoy clearer sky conditions.

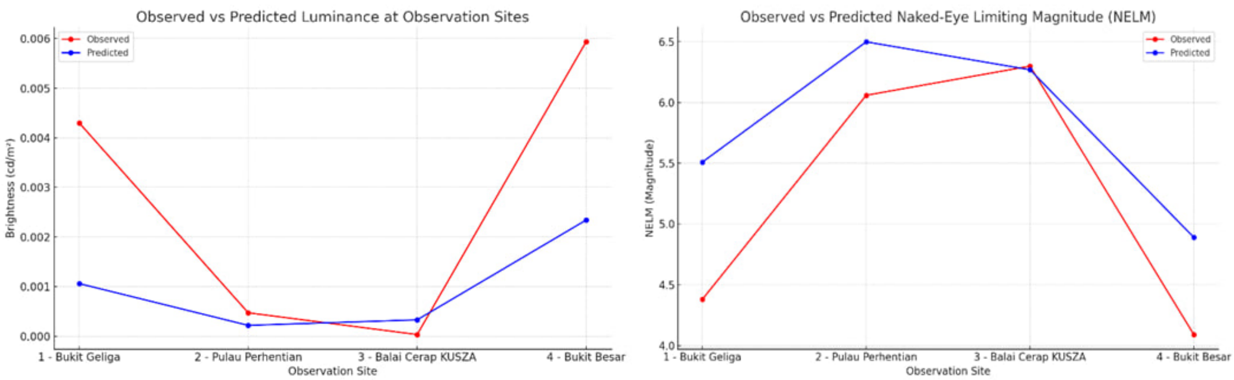
The Bortle scale classifications placed Bukit Geliga and Bukit Besar at Class 6, which is characteristic of suburban skies. Pulau Perhentian was rated as Class 5 while KUSZA Observatory was rated as Class 4, thus, indicating better conditions for astronomy-related activities. The simulation was too optimistic for Pulau Perhentian, expecting more cloud cover than would be actually present. However, differences in anticipated conditions were not nearly as stark as in Bukit Besar and Geliga.



(a) (b)

Fig. 2. Line chart for observed and predicted sky brightness (a) and Bortle scale (b)

The luminance results confirmed these findings. Bukit Dayang registered the greatest level of brightness (5.935 × 10-3 cd/m²), followed closely by Bukit Geliga (4.300 × 10-3 cd/m²). Both locations exhibited significantly higher levels of brightness than the simulations, thus indicating the presence of more artificial light in the area. In contrast, Pulau Perhentian and KUSZA Observatory displayed lower levels of brightness, more consistent with the simulated predictions. These findings suggest that Pulau Perhentian and KUSZA Observatory have darker skies, making them more suitable for new crescent moon sightings. The NELM results registered similar patterns with Bukit Geliga and Bukit Besar, scoring 4.38 and 4.09, respectively, which translates to too brilliant a lustre for observing fainter stars. Pulau Perhentian and KUSZA Observatory on the other hand had higher scores of 6.06 and 6.3, respectively, which indicates fair sight of faint stars and better sighting conditions.



(a) (b)

Fig. 3. Line chart for observed and predicted luminance (a) and NELM (b)

3.2 Correlation Between Brightness Metrics

This study analysed the actual sky brightness measured at the four official new crescent moon observation sites in Terengganu (Bukit Geliga, Pulau Perhentian, KUSZA Observatory and Bukit Besar), in comparison to the values predicted by satellite-based models. The metrics used were SQM (sky brightness), luminance (Candela in cd/m²), NELM (eye visibility of stars) and Bortle scale (sky quality class).

According to SQM measurements, most locations had a strong similarity between observed data and predicted data. Pulau Perhentian and KUSZA Observatory had values indicating that their skies were as dark as predicted, meaning that they posted congruous values. Bukit Geliga and Bukit Besar had lower-than-predicted

SQM values, meaning that the sky appeared to be brighter than expected with greater illumination from nearby lights.

The same pattern of results was also observed for luminance measurements, which is the opposite of darkness. Pulau Perhentian and KUSZA Observatory posted values as predicted, whereas Bukit Besar and Bukit Geliga showed higher than predicted brightness values, which indicates that the two latter sites experienced greater light pollution than previously thought.

NELM indicates the number of stars that can be viewed without the aid of telescopes and displays a strong correlation with SQM. The higher the SQM, the more stars are visible, and this association was well within the expected values. Pulau Perhentian and KUSZA Observatory surpassed expectations by having the best results amongst all the observation sites.

As with the rest of the sites, both observed and predicted Bortle scale values (1 being dark and 9 bright) were the same. Bukit Besar and Bukit Geliga had slightly lower than predicted values, which can be attributed to local light sources. Hence, the correlation was slightly lower because of this subjective nature.

In summary, all the sites had a good alignment between actual measurements and predictions, most prominent being Pulau Perhentian and KUSZA Observatory. Bukit Besar and Bukit Geliga were both deemed still acceptable for carrying out *hilal* observations, although they presented slightly lower than expected sky conditions. This shows that using predicted and observed data provides a better understanding of each location's sky quality.

3.3 Influence on the New Crescent Moon's Visibility

Visibility of the new crescent moon is highly influenced by the sky's brightness, particularly at sunset when the moon is positioned low in the horizon and the sun has just set. Data indicate that moon sighting is best performed at Pulau Perhentian and KUSZA Observatory since their SQM and NELM values are higher and luminance is lower. These sites have been found to maximize the contrast between the crescent and the surrounding sky. Conversely, Bukit Geliga and Bukit Besar are at lower altitudes and pose greater NELM values leading to poor visibility of the crescent in less than ideal conditions. Observers at these locations are likely to struggle when determining crucial religious dates, such as the onset of Ramadan or Eid, when the crescent needs to be visible.

3.4 Influence of Elevation on Sky Brightness Observation

It has been previously stated that darker skies correlate with higher elevation due to thinner air that lacks moisture, particles and light, which leads to the scattering of light. Garstang theorised that these factors should decrease pollution caused by light, resulting in brighter skies [10]. However, this study shows that elevation alone is insufficient for guaranteeing a dark sky, especially when there are nearby sources of artificial light.

According to the brightness data based on SQM, Bukit Besar was the highest sub-region with an elevation of 138 meters, but surprisingly recorded the lowest SQM of 18.15 mag/arcsec². Its proximity to Kuala Terengganu, which has an abundance of artificial lighting, greatly affects it. At 20 meters of elevation, Bukit Geliga also recorded an SQM of 18.5, which is also low in comparison to other areas due to the presence of roads, houses and industrial areas in the vicinity of Kemaman. In contrast, Pulau Perhentian, which is 8 meters above sea level, recorded a SQM of 20.9 and displayed a significantly darker sky. The reason for this is its distance from cities that allows it to stay unobstructed by city lights, paired with minimal lighting resources. KUSZA Observatory, situated at an elevation of 160 feet (approximately 48 meters), is perched on a forested hill, offering naturally dark skies with an SQM reading of 21.33 mag/arcsec², ideal for astronomical observations [5]. The controlled lighting in the area also provides it with the lowest SQM value recorded in the forested hill.

These results demonstrate that although elevation may be beneficial, the nearby light pollution and level of protection a site has from surrounding lights are far more influential on the darkness of the sky. This confirms previous studies by Falchi, which contended that some remote well-shielded areas could have substantially darker skies at lower elevations [17].

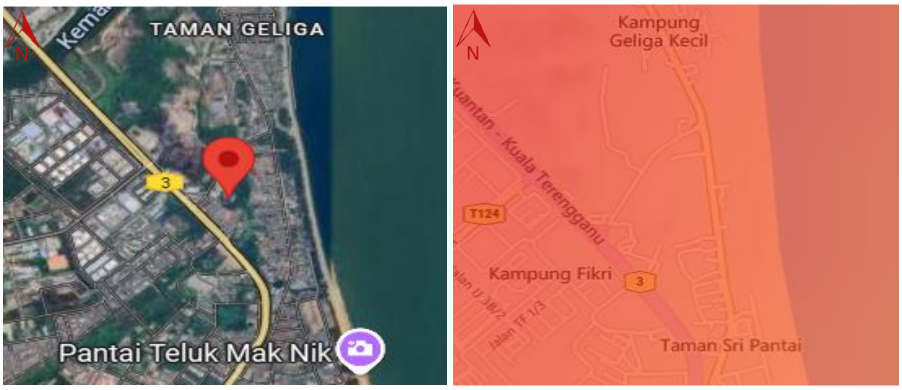
3.5 Sources of Light Pollution at Each Site

The study sites were chosen as they receive different light pollution patterns. Fig 4, Fig 5, Fig 6 and Fig 7 illustrate the spatial distribution of light pollution around each of the four studied locations. The colour gradation in each subfigure represents different intensities of artificial light as captured by night-time satellite images (data taken in 2025). Bright yellow and white tones reflect urbanized regions with strong light pollution, while street lighting and industrial activity contribute to light pollution. Depopulated areas and forests, characterized by minimal artificial lighting are depicted in darker shades of blue and black, indicative of lower light pollution. This visual scale indicates the degree to which each site's geographic encroaching light sources vary and subsequently degrade the night sky's visibility. The compass orientation allows the identification of principal directions of light intrusions, which gives additional contextual meaning and better understanding of the light source's relation to the observation station.

Bukit Geliga is situated next to the Kemaman urban and industrial zone, which is influenced by highways and residential lighting as well as industrial operations, such as oil refineries and factories. These are most likely the main sources of the increased sky brightness observed.

Bukit Besar is adjacent to the centre of Kuala Terengganu and the hill is dominated by city lights emanating from houses, commercial buildings and public utilities. This explains the high brightness and low NELM values recorded at this location.

As an island, Pulau Perhentian is shielded from light pollution from the mainland. Though there is tourism-related lighting, especially during peak seasons, its remoteness still renders it one of the darkest places ideal for moon sighting. KUSZA Observatory is on top of a small hill in the Kem Merang area. The area is protected by vegetation and light pollution is lower here because it is intended for astronomical education and public outreach purposes. These factors make it suitable for observing the night sky. This study established that employing multiple brightness metrics concurrently provide a better assessment of sky conditions and light pollution at the observation sites. Pulau Perhentian and KUSZA Observatory most definitely possess optimal sky conditions for new moon observations, while Bukit Geliga and Bukit Besar need more stringent illumination regulation control or perhaps rethink their status as official moon sighting stations.

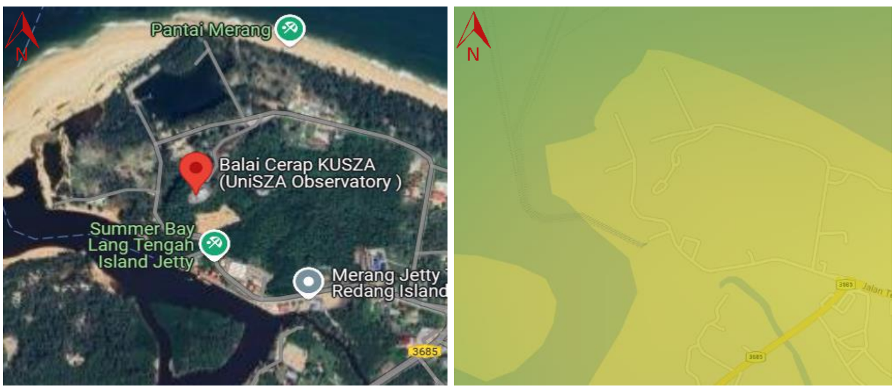


(a) (b)

Fig.4. Light pollution at Bukit Geliga: (a) satellite view (b) predicted (SQM value) brightness with color gradients intensity

(a) (b)

Fig.5. Light pollution at Pulau Perhentian: (a) satellite view (b) predicted (SQM value) brightness with color gradients intensity



(a) (b)

Fig.6. Light pollution at KUSZA Observatory: (a) satellite view (b) predicted (SQM value) brightness with color gradients intensity.

(a) (b)

Fig.7. Light pollution at Bukit Besar: (a) satellite view (b) predicted (SQM value) brightness with color gradients intensity

4.0 Conclusion

This study investigated sky brightness at four new crescent moon sighting sites in Terengganu, namely Bukit Geliga, Pulau Perhentian, KUSZA Observatory and Bukit Besar. It aimed to determine how these sites differ when observing the New Crescent Moon by measuring the sky's brightness and visibility of stars, while comparing the values with predicted data.

It concluded that the four official New Crescent Moon observation sites in Terengganu, including Bukit Geliga, are still within reasonable light pollution limits. According to the multi-brightness analysis, the current sky conditions at all the sites can most likely enable detection of the New Crescent Moon. Although some reports suggest that Bukit Geliga is not a favourable location, the data presented in this study indicate that moon sightings are still possible given the prevailing light pollution conditions. MAIDAM and the Terengganu State Mufti Department need to build on this initial evaluation and develop an open data platform for managing optimal sky brightness levels at these official sites. Creation of a national (Malaysia) and local (Terengganu) light pollution monitoring mechanism and data collection system should be developed. There should also be an *ad hoc* administrative order on policy that designates these sites as protected dark sky areas in Terengganu for sustained New Crescent Moon observational activities.

An automated system for monitoring light pollution should be developed in the future, building upon the methods previously implemented by Sabri and Nasir [18][19].

Acknowledgements

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References

[1] Falchi, F., Cinzano, P., Duriscoe, D., et al. (2016). The new world atlas of artificial night sky brightness. Science Advances, 2(6), e1600377.

[2] Barentine, J. C., Wallner, S., & Kocifaj, M. (2024). Towards future challenges in the measurement and modelling of night sky brightness. MNRAS, 527(3), 5553–5558.

[3] Cinzano, P., Falchi, F., & Elvidge, C. D. (2001). The first world atlas of the artificial night sky brightness. MNRAS, 328(3), 689–707.

[4] Herdiwijaya, D., Satyaningsih, R., Prastyo, H. A., Arumaningtyas, E. P., Sulaeman, M., Setiawan, A., & Yulianti, Y. (2020). Measurements of sky brightness at Bosscha Observatory, Indonesia. Heliyon, 6(8).

[5] Umar, R., Azan, M. A. I. A., Sabri, N. H., Ngah, N., Zulkeflee, A. N., Mohamad, A. E., ... & Nasir, A. L. A. M. (2023). Model Reruang Magnitud Kecerahan Langit Di Balai Cerap KUSZA, Universiti Sultan Zainal Abidin (UNISZA). Sains Malaysiana, 52(10), 2943-2954.

[6] Bely, A. H., Nasir, A. L. A. M., Umar, R., Chik, W. M. Y. W., Husaini, R., Othman, M. S., & Rakhmadi, A. J. (2024). Empowering Astronomical Exploration: Advancement of New Moon Observation Devices in Sarawak, Malaysia. Iraqi Journal of Science, 6154-6162.

[7] Cinzano, P. (2005). Night sky photometry with Sky Quality Meter. ISTIL Internal Report.

[8] Faid, M.S., Husien, N., Shariff, N.N.M., Ali, M.O., Hamidi, Z.S., Zainol, N.H., & Sabri, S.N.U. (2016). Monitoring the level of light pollution and its impact on astronomical bodies naked-eye visibility range in selected areas in Malaysia using the sky quality meter. 2016 IEEE International Conference on Industrial Engineering, Management Science and Application (ICIMSA), 1-6.

[9] Cinzano, P. (2007). Report on Sky Quality Meter, Version L. ISTIL Internal Report.

[10] Garstang, R. H. (1986). Modeling the Effects of Light Pollution on the Visibility of the Night Sky. PASP, 98, 364–375.

[11] Bortle, J. E. (2001). Introducing the Bortle Dark-Sky Scale. Sky & Telescope, 101(2), 126.

[12] Knoll, H. A. (1946). The visibility of faint stars. Journal of the Optical Society of America, 36(10), 715–716.

[13] Tahar, M. R., Kamarudin, F., Umar, R., Kamarudin, M. K. A., Sabri, N. H., Ahmad, K., Abdul Rahim, S., & Baharim, M. S. A. (2017). Spatial model of sky brightness magnitude in Langkawi Island, Malaysia. Research in Astronomy and Astrophysics, 17(4), 037.
[14] Bely, A. H., Umar, R., Sabri, N. H., Abidin, Z. Z., Nasir, A. L. A. M., Ismail, I., ... & Rakhmadi, A. J. (2024, December). Light Pollution Monitoring Through Zenithal Sky Brightness at Selected Malaysian Observatories. In Journal of Physics: Conference Series (Vol. 2915, No. 1, p. 012003). IOP Publishing.
[15] Shariff, N. N. M., Hamidi, Z. S., & Faid, M. S. (2017). The impact of light pollution on Islamic New Moon (hilal) observation. International Journal of Sustainable Lighting, 19(1), 10-14.
[16] Nasir, A. L. A. M., Umar, R., Yussof, W. N. J. W., Ahmad, N., Zulkeflee, A. N., Sabri, N. H., ... & Izdihar, A. I. S. (2025). New crescent moon detection using Circular Hough Transform (CHT). Astronomy and Computing, 51, 100902.
[17] Falchi, F., Cinzano, P., Duriscoe, D., Kyba, C. C., Elvidge, C. D., Baugh, K., ... & Furgoni, R. (2016). The new world atlas of artificial night sky brightness. *Science advances*, *2*(6), e1600377.
[18] Sabri, N. H., Afandi, N. Z. M., Umar, R., Safei, S., & Monstein, C. (2024, October). Automated Monitoring System for Detection of Solar Radio Bursts for CALLISTO Spectrums. International Exchange and Innovation Conference on Engineering & Sciences.
[19] Nasir, A. L. A. M., Umar, R., Yussof, W. N. J. W., Ahmad, N., Zulkeflee, A. N., Sabri, N. H., ... & Mahiddin, N. A. (2024, October). The Implementation of Hybrid Observation Technique of Hilal (HOTOH). International Exchange and Innovation Conference on Engineering & Sciences.