A Verification on Kastner Visibility Model Prediction: Case of hilal of ramadan and shawwal 1434 hijri

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ABSTRACT

Kastner visibility function model for near-Sun objects has been used to make predictions on visibility of hilal of Ramadan and Shawwal 1434 H for a number of locations within the National Hilal Observation Network. Predictions made for the mode of visual observation both using naked eye and telescope-aided observation. Due to weather constraints, the model predictions for the case of the beginning of Ramadan 1434 H (July 8, 2013) did not obtain confirmation from the entire sites. Meanwhile, for the case of Shawwal 1434 H (August 7, 2013) there were confirmations on hilal visibility from several places. We consider only the witness from Makassar that provide authentic evidence of a digital picture of hilal. Based on this, Kastner model proved capable of providing predictions in good agreement with the observational result. Interestingly, prediction of Odeh model, which is the more established one, was in opposite results with prediction of Kastner model.

Keyword: Hilal,
Hilal Visibility,
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Visibility
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1. INTRODUCTION

Babylonian stargazers have had criteria to predict the appearance of hilal (lunar crescent can be observed after conjunction), known as the Babylonian criteria. According to them, hilal can be observed if the age of the Moon since conjunction is more than 24 hours and the time difference between Sunset and the Moonset on the day of observation greater than 48 minutes. The above criteria can be understood as follows. Requirement that the age of the Moon more than 24 hours since the conjunction is to make the fraction of lunar disk that reflect sunlight thick enough to make it bright enough to be observed. Meanwhile, the time difference between Sunset and the Moonset must be greater than 48 minutes is meant to make the sky become dark enough to make hilal can be observed easily. The first point is related to object illumination, while the second one with the contribution of brightness of the twilight sky.

Kastner [1] have constructed a mathematical model to calculate the brightness of the twilight sky based on graphic of the actual brightness of the twilight sky were obtained by Barteneva and Boyarova [vide [1]] at 90 degrees zenith distance as a function of Solar depression angle and relative azimuth. Based on this model, the visibility curve for objects near to the Sun can be generated. Although the model is for celestial objects such as stars, planets, and comets, this model has been adopted also for hilal according to its characteristics that can be a point-source as well as an extended-source. The model is adapted to accommodate a mode of observation using binocular / telescope in addition to the naked eye observation. Reliability studies of Kastner model based on data of hilal and old lunar crescent can be found in Utama [2] and Utama & Efendi [3].

For Muslims, the observation of hilal is part of worship. The successful of hilal observation determines whether the new month is begun in the Islamic calendar system or Hijri system. Unfortunately, positive reports of hilal observation in Indonesia gained critics from astronomers related to the difficulty of hilal observation with certain physical parameters to be observed using naked eye. By using Kastner model this work has predicted the earliest hilal appearance of Ramadan and Shawwal 1434 H. Then the model predictions are confronted with the observation reports from the 21 observation sites within in the National Hilal Observation Network under coordination of Bosscha Observatory and the Ministry of Communication and Informatics of the Republic of Indonesia.

2. RESEARCH METHOD

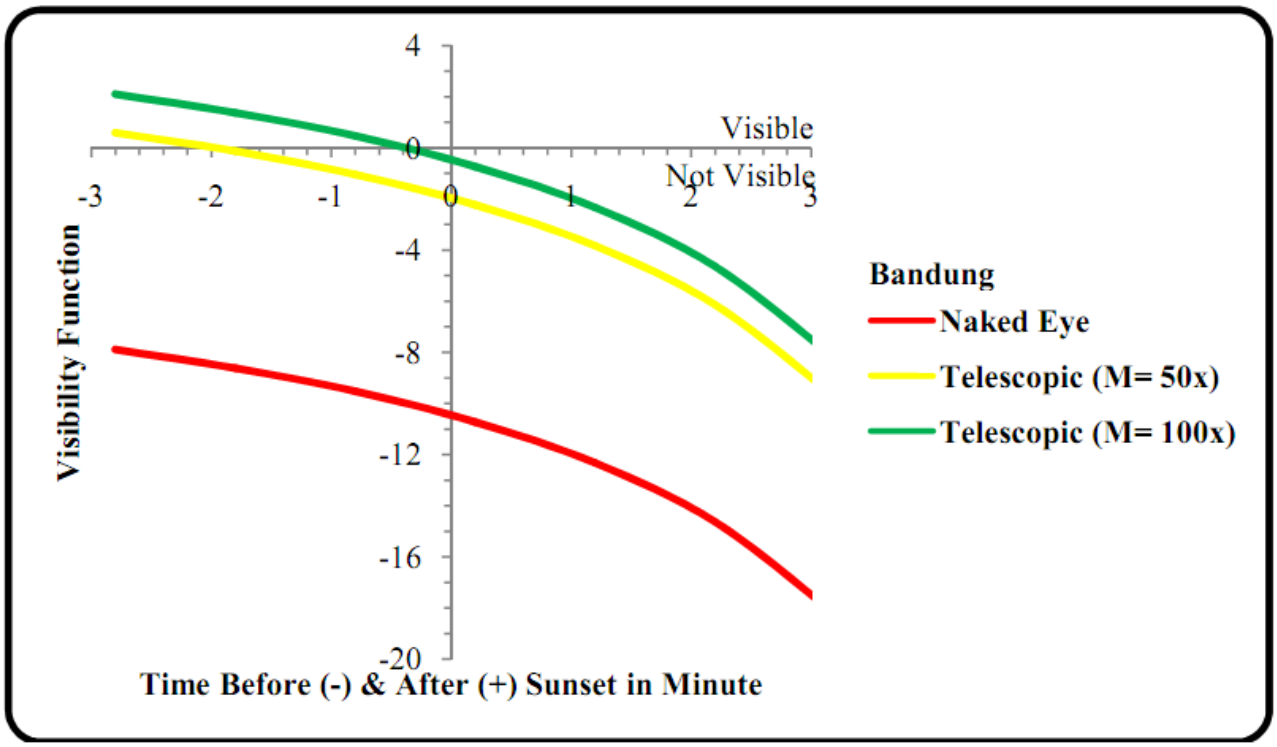
This work was conducted utilizing the physical parameters data of the Moon and the Sun for specified date of observation. The observation time was chosen on the day when the conjunction occurs before Sunset or on the next day when the conjunction occurs after Sunset. In the case of the beginning of Ramadan and Shawwal 1434 H, the observation was conducted on the same day as the day of conjunction. Predictions are given for several locations joined the consortium.

The Moon physical parameter data (zenith angle, azimuth, elongation, apparent visual magnitude and semidiameter) as well as the Sun (depression angle and azimuth) required for calculations were obtained using *MoonCalc* software version 6.0 of Monzur Ahmed [4] with topocentric (observers are located on the Earth's surface) and taking into account the effect of atmospheric refraction setting. Calculations were performed following the procedure and equations in Kastner [1]. Predictions are given for clear atmospheric conditions by using visual extinction coefficient k = 0.20 for both the naked eye and use an optical instrument (telescope) observation mode. Next the predictions are confronted with observation reports from each location and compared with the prediction which is given by Odeh [5].

3. RESULT AND ANALYSIS

Figure 1 shows the prediction of hilal visibility curve for the beginning of Ramadan 1434 H, while Figure 4 shows the predictions for the beginning of Shawwal 1434 H for observers in Bandung and Makassar. Each of these predictions include naked eye visual observation and telescopic observations that produces an angular magnification of 50x and 100x. Positive and negative visibility function values are interpreted as hilal can be observed and can not be observed respectively.

Based on Figure 1, the prediction for the observer in Bandung for both naked eye visual observation or using a telescope, hilal can not be observed after Sunset. This can be seen from the negative values of visibility function. Eventhough hilal is predicted can be observed with the 100x angular magnification telescope just before Sunset, there were no reports from this location. On the day of observation, the Moon was only for 3 minutes above the horizon after Sunset. A similar prediction applies to the location in Makassar. From Makassar hilal was predicted to be observed at the time of Sunset until 1 minute later with the help of 100x angular magnification telescope. Even in Makassar the Moon was only about 1 minute on the horizon after Sunset. However if there were positive reports on hilal observation before Sunset, the testimonies can not be used in the *istbat assembly* at the Ministry of Religious Affairs, as based on Shari'a, change of the month based on the appearance of hilal after Sunset.



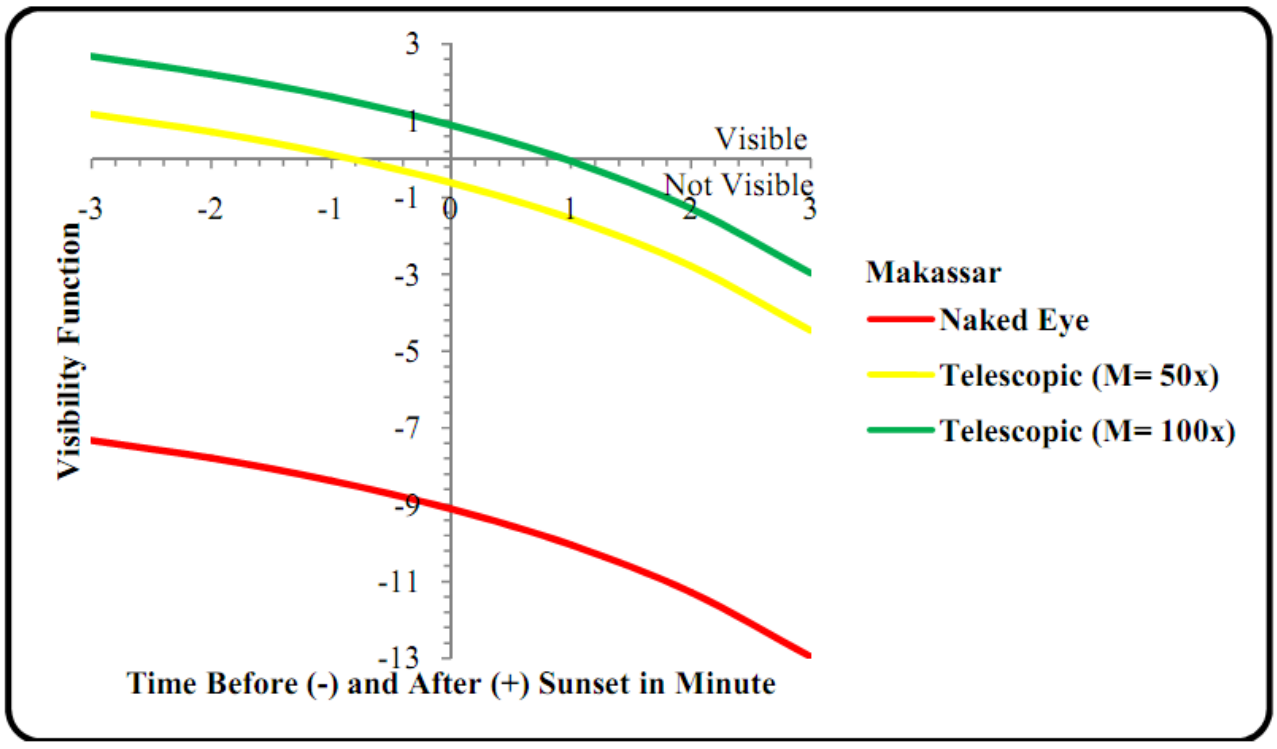


Figure 1. Visibility curve (Monday July 8 2013) for observer in Bandung (top) and Makassar (bottom)

In fact , from the 21 observation sites within the National Hilal Observation Network there were no positive reports on hilal of Ramadan 1434 H. The bad weather was the biggest obstacle factor at that time. According to the Meteorology, Climatology, and Geophysics Agency (BMKG) prediction for Monday, July 8 2013, almost all observation sites was interrupted by cloudy or rainy conditions with varying intensity. Thus, *istbat assembly* led by minister of religious affairs set month of Shaban to be 30 days, so that 1 Ramadan 1434 H coincides with Tuesday, July 9 2013 at the time of Sunset. Then observation activity on Tuesday, July 9 2013 was no longer in a crucial position because the number of days in the Islamic calendar month can not be more than 30 days. Nevertheless, observers in Kupang obtained the digital image of hilal (figure 3) as an authentic evidence for Kastner model prediction on Tuesday evening on local time within the time window had been predicted (figure 2).

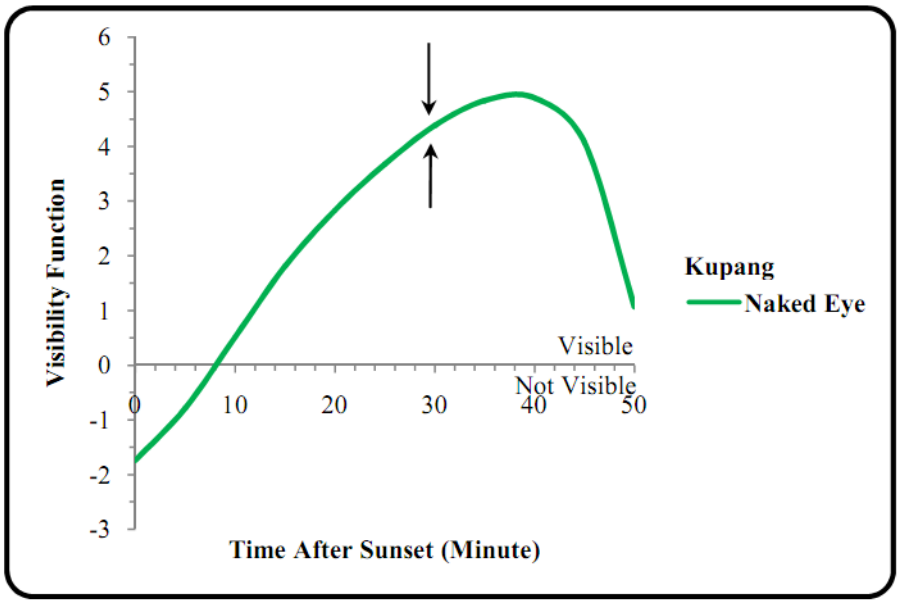


Figure 2. Visibility curve (Tuesday July 9 2013) for observer in Kupang
The time when the image captured is indicated by the arrows.

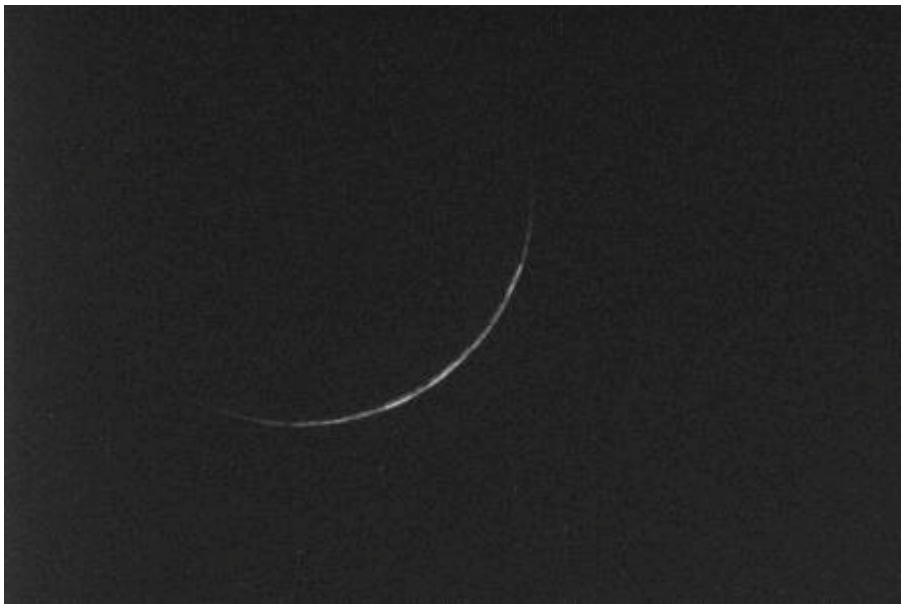
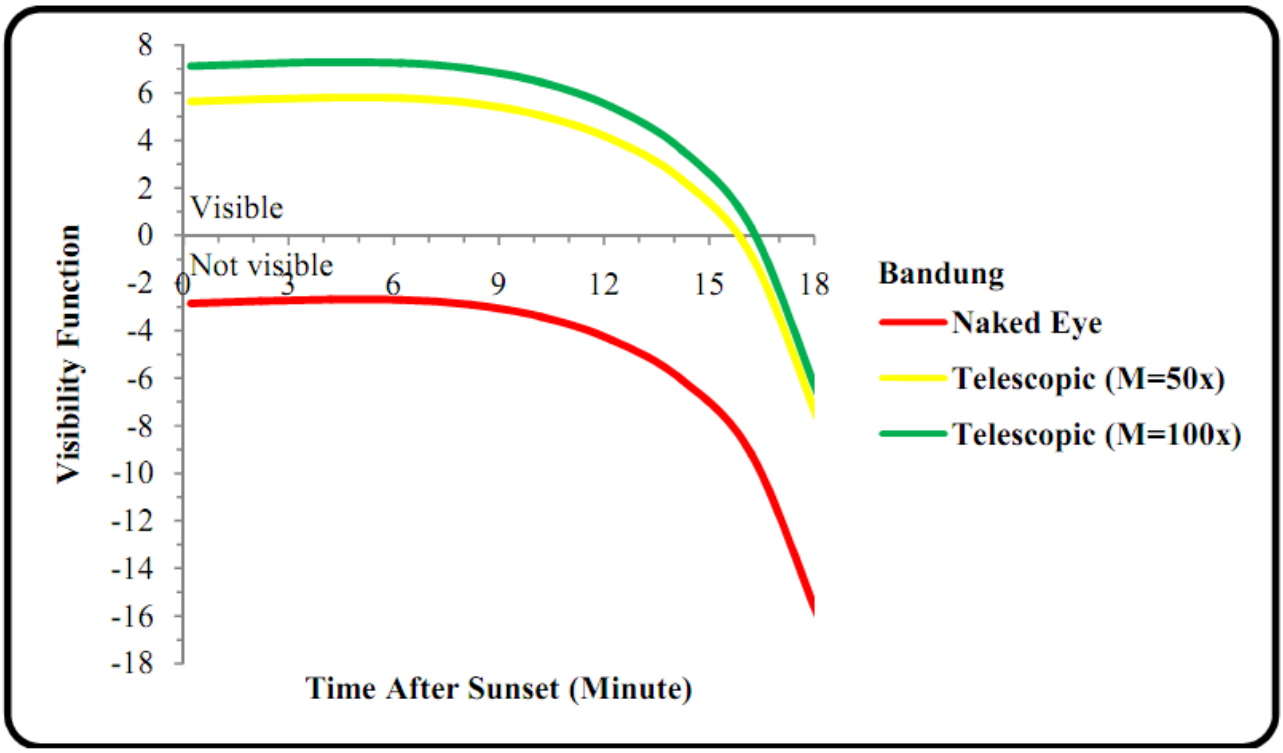


Figure 3. The digital image of hilal captured with camera and telescope
on Tuesday July 9 2013 from Kupang on 18:09 local time (Credit: Bosscha Observatory)

In figure 4 are shown the predictions of hilal visibility for Shawwal 1434 H. Although the weather remained bad as at the beginning of Ramadan, observers from Makassar reported the appearance of hilal of Shawwal 1434 H succesfully. Observers were equipped with a camera that was attached to the telescope tube to record the hilal in digital format as an authentic evidence. Based on Figure 4, the model predicts the impossibility of observing hilal using naked eye (negative visibility function), but it is still possible with the help of telescope (positive visibility function). Negative visibility function corresponds to the contrast value less than 1. Contrast is defined as the ratio between the hilal illuminance over twilight sky brightness. Only when this ratio is larger than 1 (object illuminance is more dominant than the brightness of the sky), the object is likely to be observed. Eventhough the available time window to figure out hilal of Shawwal 1434 H was relatively longer than in case of Ramadan 1434 H, weather disturbances (cloud cover around the horizon and rainy condition) makes not all locations predicted can observe hilal have the opportunity. The only positive report came from Makassar along with authentic digital image (figure 5) and had been used in the *istbat assembly*. This report verified the Kastner model prediction. Indeed there are also reports through visual observation of other places (Semarang and Tegal), but since there were no authentic evidence obtained, those reports are not used in this paper.



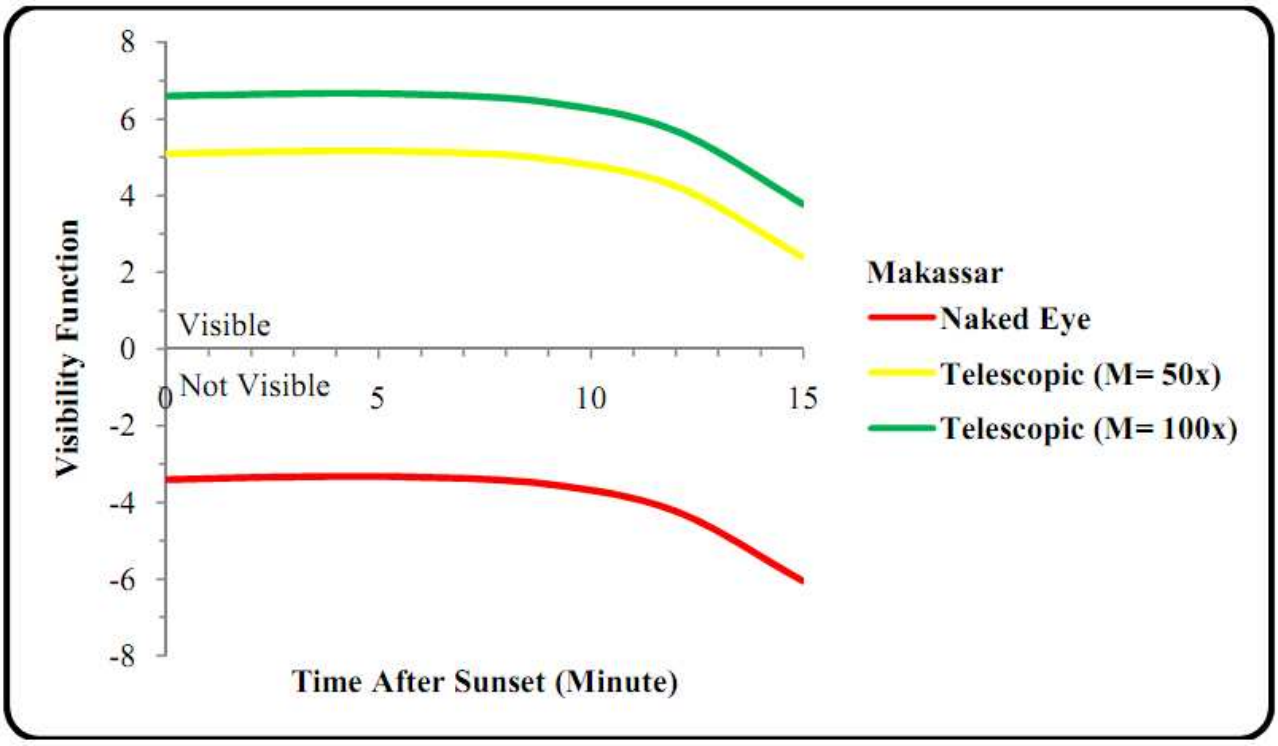


Figure 4. Visibility curve (Wednesday August 7 2013) for observer in Bandung (top) and Makassar (bottom)

Eventhough Kastner model predicts hilal could be observed by using a 100x angular magnification telescope, the fact was that the group of observers in Makassar did not try direct visual observation through the eyepiece. They only recorded the hilal images digitally. To date, Kastner model predictions for cases with high challenge (such as observations in the same day as the day of the conjunction) is difficult to obtain even with positive visibility function value, because the required necessary condition is not met, those are the clean atmospheric conditions (minimum aerosol and pollutants), there were no adverse weather (cloud cover in the line of sight of hilal or rainy condition) and the use of telescope with certain angular magnification.

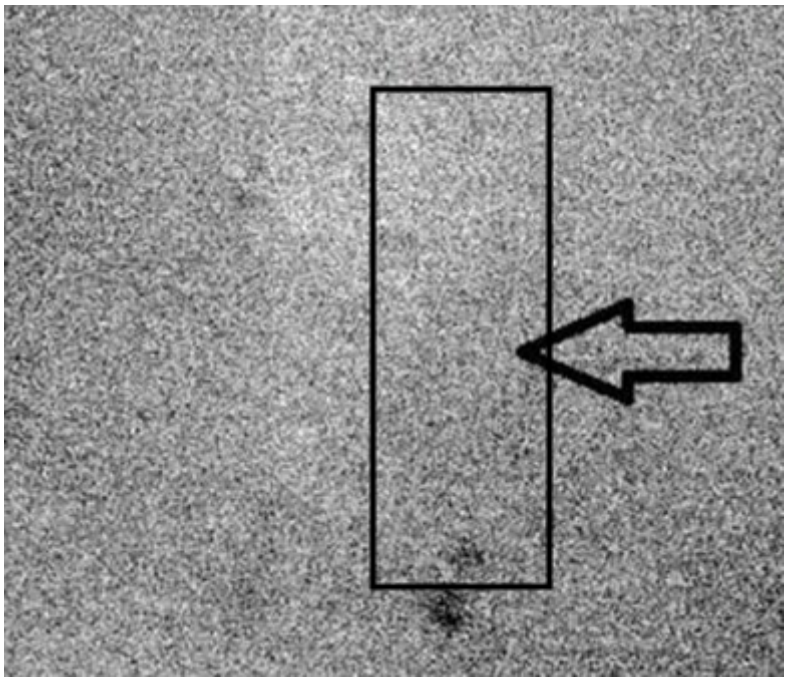


Figure 5. The digital image of hilal captured with camera and telescope
on Wednesday August 7 2013 from Makassar on 18:11 local time (Credit: Bosscha Observatory)

It is interesting to know the prediction from other model such as Odeh. Odeh model are developed based on 737 reports compiled from various sources from tropics and sub-tropic region. The appearance prediction is given by two variables, namely the altitude difference between the Moon and the Sun (no atmosphere condition) and the width of the crescent. Both of these variables are topocentric condition (calculated for an observer on the Earth's surface). Comparison between Kastner and Odeh predictions are given for each case with the same time and location. Predictions are given limited to hilal appearance after Sunset. Comparing the predictions of both models and confront to the reports, it appears that in the case of the beginning of Shawwal 1434 H Kastner model has better performance in accordance with the available evidence than Odeh.

Table 1. Models Prediction for Makassar

Cases	Kastner (1976)	Odeh (2006)
Ramadan (July 9)	Visible	Easily visible with naked eye
Shawwal (August 7)	Possible with optical aid	Not possible even with optical aid

4. CONCLUSION

Predictions had been made for the case of the earliest appearance of hilal of Ramadan and Shawwal 1434 H by using Kastner model that accommodates atmospheric contribution and twilight sky brightness. No confirmation reports for prediction on Ramadan 1434 H for the day when the conjunction occured in Makassar (Monday, July 8, 2013 with telescopic observation) because of the weather constraint. Model prediction for one day after conjunction was confirmed by report from Kupang. For the case of Shawwal 1434 H, prediction of Kastner model required the use of telescope with certain angular magnification to be able to observe hilal. Contrary to this, Odeh model stated that hilal could not be observed even using optical aid.

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