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The Effect of Iso and Shutter Speed Variations On the Quality of Dawn Light Astrophotography

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Abstract: *The setting of the exsposure is one of the important factors in producing high-quality dawn images. The ISO and shutter speed settings on Android phones have provided significant support for astrophotography, especially in dawn imagery. This study aims to analyze the effect of variations in ISO values (800, 1600, and Auto) and shutter speed (8 seconds, 10 seconds, and Auto) on the quality of dawn images through comparison. This study is a comparative quantitative study that aims to measure the influence of independent variables, namely ISO values and shutter speed, on dependent variables, namely the quality of dawn imagery in astrophotography. Data analysis was carried out using AstroimageJ software to measure the effect of ISO value setting and shutter speed on dawn image quality. Based on the results of the analysis, it can be concluded that the ISO and shutter speed value settings have a significant influence on the quality of dawn images. then ISO and shutter speed settings in Auto mode are more ideally used, because this mode can adjust to the existing lighting conditions.*
Keywords: *Astrophotography, ISO and Shutter speed, dawn image.*

Abstrak: *Pengaturan exsposure merupakan salah satu faktor penting dalam menghasilkan citra fajar berkualitas tinggi. Pengaturan ISO dan kecepatan rana pada ponsel Android telah memberikan dukungan yang signifikan untuk astrofotografi, terutama dalam pengambilan citra fajar yang memerlukan banyak cahaya. Penelitian ini bertujuan untuk menganalisis pengaruh variasi nilai ISO (800, 1600, dan Otomatis) serta kecepatan rana (8 detik, 10 detik, dan Otomatis) terhadap kualitas citra fajar melalui perbandingan. Penelitian ini merupakan kajian kuantitatif komparatif yang bertujuan untuk mengukur pengaruh variabel independen, yaitu nilai ISO dan kecepatan rana, terhadap variabel dependen, yakni kualitas citra fajar dalam astrofotografi. Analisis data dilakukan menggunakan perangkat lunak AstroimageJ untuk mengukur pengaruh pengaturan nilai ISO dan kecepatan rana terhadap kualitas citra fajar. Berdasarkan hasil analisis, dapat disimpulkan bahwa pengaturan nilai ISO dan kecepatan rana memberikan pengaruh signifikan terhadap kualitas citra fajar Ketikkan abstrak Anda di sini.*
Kata Kunci: *Astrofotografi, ISO dan Shutter speed, Citra Fajar.*

A. Introduction

The observation of the shadiq dawn, which marks the beginning of the entry of the Fajr prayer time, has long been the focus of study in the science of astronomy (Ilmu Falak).[1] Which Fajr prayer is a mandatory worship for Muslims. [2] However, accurately determining the dawn time of Sadiq is still a challenge, given the complexity of the astronomical phenomena involved and the different interpretations of the related postulates.[3]

[1]Lutfi Fuadi, "Fajar Penanda Awal Waktu Subuh Dan Puasa," 2021.
[2]Nur Qomariyah, "Penentuan Awal Waktu Salat (Awal Waktu Salat Asar, Magrib, Dan Isya Berdasarkan HadisNabi)," *Al-Afaq* 2, no. 2 (2020).
[3]Unggul Suryo Ardi, "Problematika Awal Waktu Shubuh Antara Fiqih Dan Astronomi," *Al-Afaq*, 2020.

Along with the development of technology, especially in the field of astrophotography, the observation of dawn images to determine the beginning of the dawn prayer time is getting easier to do. Currently, to capture quality dawn images, you can use an Android smartphone, which already has manual settings that provide high flexibility for control the quality of dawn images. Thus, astronomy scientists can take advantage of this technological advancement in seeing the quality of dawn images.[4] Engaging in astrophotography, especially in low-light conditions, requires an understanding of fundamental photography techniques, specifically long exposure or slow-speed methods characterized by low shutter speeds.[5] Luminance or lack thereof in an image, commonly referred to as exposure, is affected by the quality of the light captured by the quality of the light captured by the camera sensor. The light intensity can be adjusted through three main components found in the camera: aperture, ISO, and shutter speed. By manipulating these three elements, the photographer can adjust the amount of light that enters the lens and then reaches the camera sensor.[6]

ISO and shutter speed settings are key factors in producing quality dawn astrophotography. ISO (International Standardization Organization) serves as an indicator of the camera's sensitivity to light, in particular a lower ISO value is associated with a decrease in sensitivity to light, while a higher ISO value indicates an increase in sensitivity to light. Therefore, by adjusting the ISO, a camera will be able to capture details in low light conditions such as dawn. Shutter speed refers to the length of time the camera shutter stays open, which allows light to reach the sensor. A long shutter duration allows more light to enter the camera and the shorter the shutter opens, the shorter the light that enters.[7] As such, finding the right balance between ISO and shutter speed is crucial to producing detailed, clear, and noise-free images of dawn. So the selection of these two variables is the focus of the research because it is based on its central role in controlling the amount of light that enters the camera sensor, which is the main determining factor in the quality of astrophotographic images.

This study aims to uncover how variations in ISO and Shutter speed affect the quality of dawn images in astrophotography. By taking a combination of different ISO and shutter speed values, the study will observe changes in the noise level in the resulting image. Then the author will also reveal whether the difference in ISO and Shutter speed variations has an effect on the appearance of dawn images. The results of this research can be used as a guide for photographers

[4]Sudarmadi Putra, "Fajar Shodiq Dalam Perspektif Astronomy," *Sanaamul Quran* 2, no. 2 (2022).
[5]Azwin Azwar and Didit Endriawan, "Bad Impact Masculinity: Visualisasi Fotografi Dengan Menggunakan Teknik Slow Shutter Speed Dan Light Painting," *E-Proceeding of Art & Design* 10, no. 4 (2023).
[6]Aidil Syahputra and Asrul Sani, "Analisis Pemotretan Foto Menggunakan Teknik Segitiga Exposure Pada Produk Makanan Kemasan," *JBPM* 1, no. 2 (2023).
[7]Aidil Syahputra and Asrul Sani.

who pursue astrophotography because by knowing the camera settings, especially the right ISO and Shutter speed settings, you will get high-quality dawn images.

B. Method

This study is a quantitative study [8] which aims to measure the effect of ISO and Shutter speed variations on the quality of dawn light astrophotography comparatively. This comparative method the author chooses to compare the results of image archiving with the use of different ISO and Shutter speeds. The dependent variable in this study is the quality of dawn images, while the independent variables in this study are ISO and Shutter speed in various variations. Through analysis using the AstoimageJ application, it is hoped that a significant relationship can be found between these variables. The results of this study are expected to identify the combination or variation of the optimal ISO and Shutter speed values to produce the best quality dawn light astrophotography.

C. Results and Discussion

1. Astrophotography

Astrophotography is a combined term that blends the disciplines of astronomy and photography. Astronomy is a scientific field dedicated to the study of celestial bodies, such as stars, planets, and moons, as well as various phenomena that occur outside the Earth's atmosphere. In contrast, photography refers to the practice of capturing and manipulating light to achieve the desired visual result. The term "photography" itself comes from the Greek words "phos" which means light, and "graphe" which means to write or draw. Thus, literally it can be interpreted as "writing with light" further, photography not only serves as a means to document important events but also as an artistic medium that has aesthetic value and conveys a message to the audience.[9]

The term "astrophotography" is a combination of the words "astronomy" and "photography", which effectively connects the two concepts and thus narrows the scope of the latter. Photography, by definition, refers to the process of taking pictures through the recording of light reflected from an object to a light-sensitive medium. This definition distinguishes photography from other forms of artistic expression, such as writing or painting, which do not specifically involve light in this way. Similarly, astrophotography is defined as photography focused on astronomical objects, which distinguishes it from general photography by its exclusive emphasis on celestial phenomena. So astrophotography can be understood as a special art to capture light from astronomical subjects. [10]

[8]Zahara Fadilla et al., "Metodologi Penelitian Kuantitatif," 2023, https://www.researchgate.net/publication/370561251

[9]Ahmad Junaidi, *Astrofotografi (Adopsi Dan Implementasinya Dalam Rukyatul Hilal Di Indonesia)* (Yogyakarta: Q-Media, 2021).

[10]Sani Sinarsana, "Mengenal Dan Memahami ISO, Aperature, Shutter speed Dalam Fotografi."

2. AstroimageJ

AIJ is a general-purpose astronomical image processing tool, plus it provides an interface to simplify the interactive processing of image sequences. The current release (version 3.1.0) includes the following features and capabilities, with (I) showing the features provided by the underlying ImageJ platform, (I+) showing the upgraded ImageJ features, (A+) showing features based on the Astronomy plugin package, but with significant new capabilities, and (N) showing the new features available in AIJ, but not available in ImageJ or the Astronomy plug-in package.[11]

AIJ provides interactive interfaces for single-aperture photometry and multi-aperture differential photometry. The differential photometry interface is designed to automatically process time series images and measure the transit light curves of exoplanets, eclipse binaries, or other variable stars, optionally in real time while observations are being made. The MP (Multi-Plot) module provides a multi-curve plotting facility that is tightly integrated with differential photometry and light curve mounting. MA (Multi-Aperture) can start MP (Multi-Aperture) automatically, or MP (Multi-Aperture) can be started manually by clicking the corresponding icon on the AIJ Toolbar. If the measurement table has been created by the MA or opened from the OS (operating system), then Multi Aperture will automatically create a plot based on the last plot setting. Alternatively, plot templates can be saved and restored to format commonly created plots with ease. Plotting controls are accessed in two user interface panels.[12]

3. Exposure in Photography

The camera functions as a basic instrument to capture and present light through its sensors. The incoming light is then converted by the camera sensor into a visual image. Exposure, in this context, refers to the level of brightness or illumination that occurs in the image, as well as the measurement of the intensity of light received during the shooting process. Insufficient light will result in a dark-looking image, a phenomenon known as underexposure (EU), while excessive light will result in an overexposed image, this is called overexposure (OE). To get an optimal image that balances brightness and darkness, it's important to use the right exposure settings.[13]

The concept of lighting, often referred to as the lighting triangle, includes three basic elements: ISO, aperture, and shutter speed. The interaction between these three components is crucial in achieving the desired exposure in photography practice. Changes to one element will inevitably affect the others, and the specific combination of these three factors will ultimately determine the luminosity of the image.

[11]M. Nur Iskandar Fajri, "Uji Komparasi Olah Citra Fajar Menggunakan Metode Perbandingan Internsitas Cahaya Dan 3D Surface Pada Aplikasi AstroimageJ" (2024).

[12]M. Nur Iskandar Fajri.

[13]Nabila Anggraini, Azwardi, and Isnainy Azro, "Pembuatan Media Pembelajaran Segitiga Exposure Dalam Teknik Fotografi Dasar Berbasis Virtual Reality" 1, no. 1 (2021): 30–30.

a. Aperture

Aperture refers to an important component of a camera lens that serves to regulate the amount of light that penetrates the camera body. Aperture is a significant determinant of the intensity of light captured in a photo. A larger aperture allows for more light to enter, while a smaller aperture limits the entry of light. Furthermore, the aperture plays an important role in manipulating depth of field: a wide aperture results in a shallow depth of field, which results in a blurred background, while a narrow aperture results in a wide depth of field, which ensures that all elements in the frame are displayed in sharp focus.[14]

b. Shutter Speed

Shutter speed refers to the length of time the camera shutter remains open, allowing light to reach the sensor. The extended shutter speed allows more light to enter the camera, resulting in brighter images. Starting from 1/4000 second to 30 seconds. This setting is adjusted on the camera body, not on the lens. In addition, shutter speed has a significant impact on motion capture. Fast shutter speeds are essential for freezing the movement of fast-moving subjects, this setting can be used in contexts such as sports forensics. In contrast, slow shutter speeds can be used to convey movement, capturing phenomena such as the movement of the sun or the gradual transition of light during dawn and dusk.[15]

c. ISO

ISO serves as an indicator of the sensitivity of the camera sensor to light. The ISO scale usually starts at a value of 50, 80, or 100 and can be extended to 3200 or even higher. A lower ISO value indicates a reduced sensitivity to light, while a higher ISO value indicates increased sensitivity. However, the use of high ISO settings can negatively affect the image quality, resulting in the appearance of artifacts known as noise, which can make the photo grainy and reduce fine details. Despite these drawbacks, higher ISO settings are often important in mature lighting conditions, such as dimly lit environments.

4. Detecting Dawn Appearance Using AstroimageJ Application

In this study, researchers used an android camera to capture images of dawn, by setting the ISO and Shutter speed on the android camera to get the desired image quality. To see a comparison of the use of good ISO and Shutter speed, researchers eliminated variables that affect the appearance and quality of dawn images, such as light pollution, moonlight, etc. So this study was conducted in a place with low light pollution, namely Karimunjawa Island. The variations of ISO and Shutter speed used are:

[14]Hastuti and M. Basithussyarop, "Problematika Astrofotografi Dalam Rukyatul Hilal," *El-Falaky* 6, no. 1 (2022).

[15]Aidil Syahputra and Asrul Sani, "Analisis Pemotretan Foto Menggunakan Teknik Segitiga Exposure Pada Produk Makanan Kemasan."

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Table 1: ISO and Shutter speed setting data

No	ISO	*Shutter speed*
1	800	8 s
2	1600	8 s
3	1600	10 s
4	Auto	Auto

From the various variations that the author took, the author took pictures simultaneously at the same location on Karimunjawa Island on July 28, 2024 at 04.00 to 05.00 WIB. The results of the images that have been taken from observations before dawn to after dawn, were analyzed using the AstroimageJ application. The AstroimageJ application is a tool for processing general-purpose astronomical images, plus it provides an interface to simplify the processing of image sequences interactively.[16] The differential photometry interface is designed to automatically process time series images and measure the light curves of transiting exoplanets, eclipsing binaries, or other variable stars, optionally in real time as observations are being made.. [17] The differential photometry interface is designed to automatically process time series images and measure the light curves of transiting exoplanets, eclipsing binaries, or other variable stars, optionally in real time as observations are being made. After getting the results from the AstroimageJ application, the data will be verified using Microsoft Excel to see when the light starts to appear, the picture of the graph is as follows:

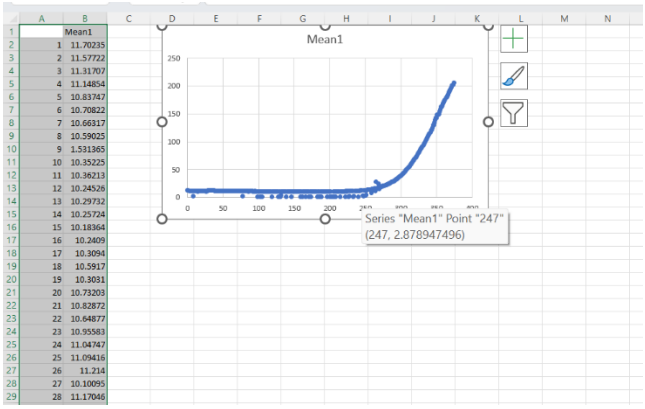

Figure 1: Graph from Microsoft Excel

[16]M. Nur Iskandar Fajri, "Uji Komparasi Olah Citra Fajar Menggunakan Metode Perbandingan Internsitas Cahaya Dan 3D Surface Pada Aplikasi AstroimageJ."

[17]Karen A., John F. Kielkopf, Keivan G. Stassun, and Frederic V. Hessman Collins, "Astroimagej: Image Processing and Photometric Extraction for Ultra-Precise Astronomical Light Curves," *The Astronomical Journal*, no. 2 (n.d.): 5–5.

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From the graph above, it can be seen that if the cursor is directed to the graph where the curve begins to rise, an image will appear at which point the light begins to appear. As in the image below, the 274th image was shot at 04:46 WIB:

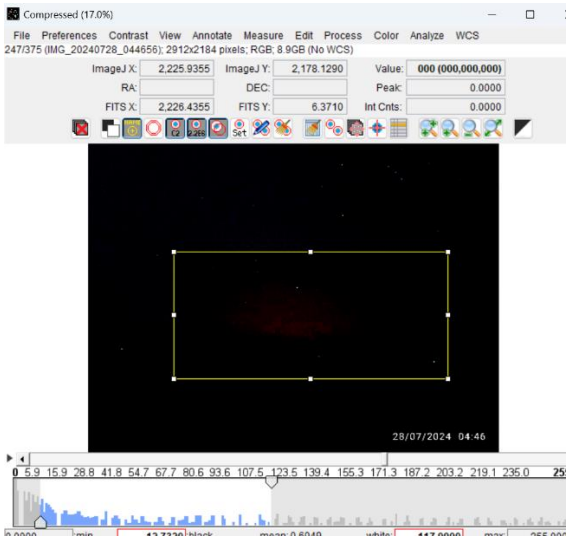


Figure 2: Shooting time as seen from the AstroimageJ application

After that, we will enter the data into the Accurate Times application. The data used is as follows:

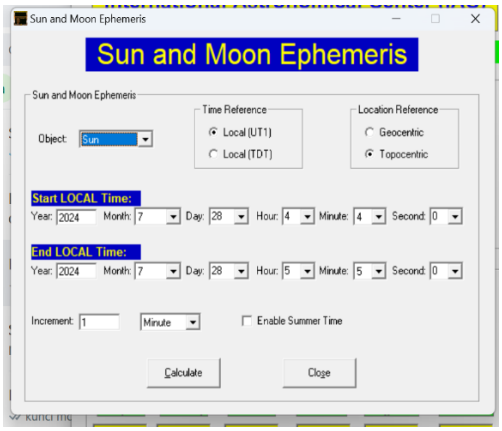


Figure 3: Sun and Moon Ephemeris

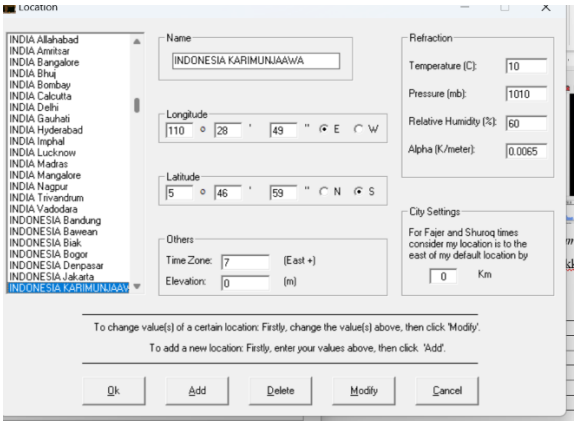


Figure 4: Location

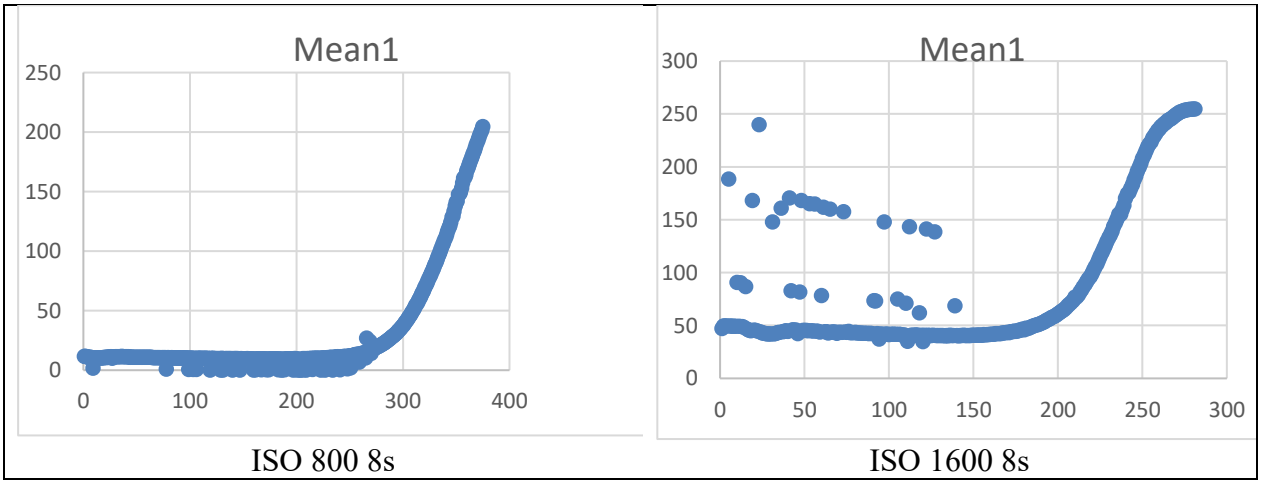
From the data above, the results of the Altitude or height of the sun will be obtained from the Accurate times application. This data shows the results of the height of the sun from the

images that have been observed and verified using the AstroimageJ and Microsoft Excel applications..[18]

5. The Effect of Variations in ISO and Shutter Speed on the Quality of Dawn Image Astrophotography

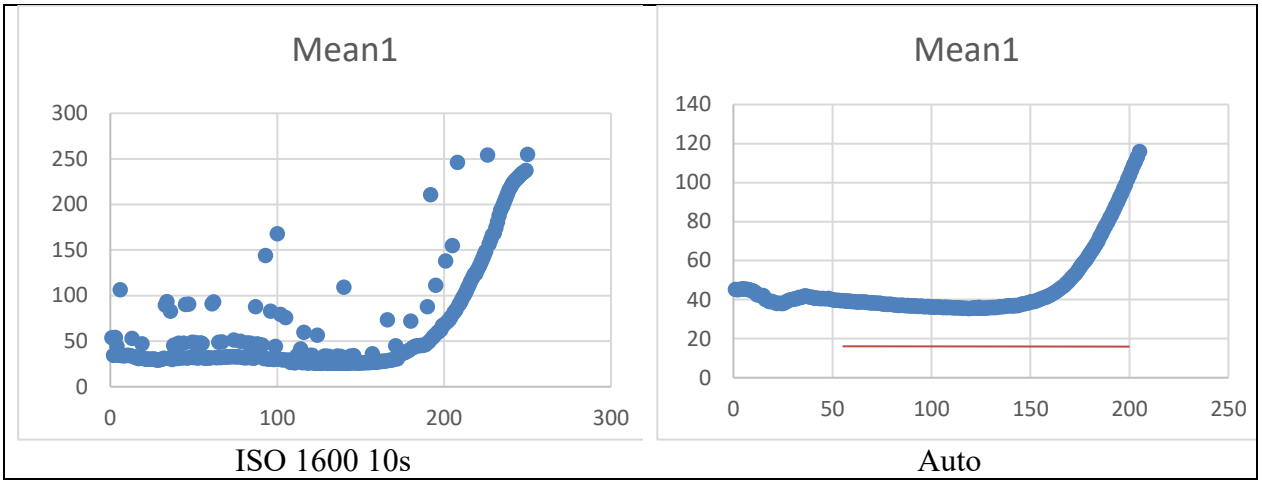
Currently, there are many mobile phone users whose cameras already have very sophisticated settings. One of them is the ISO and Shutter speed settings. ISO and Shutter speed settings are very much needed in taking pictures that require high light intensity, so in this case it is very much in line with the observation of the Dawn image which is very minimal with light. For deeper knowledge, researchers took samples of several variations of ISO and Shutter speed that will be used, namely ISO (1600, 800, and Auto) while the researcher used 10s and 8s Shutter speed.

In taking ISO and Shutter speed samples above, the author took samples where the sensitivity was medium for ISO 800 Then High sensitivity for ISO 1600, and Auto mode for standard sensitivity. From these three samples, the author will compare whether there is an effect of ISO and Shutter speed on the quality of the Dawn light that the author observed. To compare or analyze the data, the author uses the AstroimageJ application, which in this case is an application that is often used to process light intensity data. Then to see the light visibility graph, the author uses Microsoft Excel and then verifies it using the Accurate time application. So the author gets the following graphic results:



ISO 800 8s ISO 1600 8s

[18] Grady Boyce, "The AstroimageJ Cookbook," 2019.



ISO 1600 10s Auto

Based on the graph above, ISO 800 with Shutter speed 8 has a stable curve but there are slightly damaged images, we can both see in the first graph, there are spots that are not straight with the curve or we can call them irregular spots. The author concludes that the factor that causes the spots to be irregular is due to instability in the camera blown by the wind, this can indeed happen because the use of ISO and Shutter speed does make the sensor more sensitive to light but can also increase noise in the image due to instability, so that the captured image is inaccurate or looks noisier.

Then for graph number 2, namely with ISO 1600 settings and Shutter speed 8. Similar to ISO 800 which has irregular spots, the use of ISO 1600 8s is even more irregular and there are many spots that come out of the curve. Spots that come out of this curve illustrate that the image is damaged or noisy, this is because the light sensitivity is very high, namely 1600 and with a shutter speed of 10 s, it is very possible for the image to become noisy or damaged so that the curve becomes irregular. It can be concluded that the use of a higher ISO will damage the image quality.

The third graph uses ISO 1600 with a shutter speed of 10s. To compare the effect of shutter speed on the quality of the dawn image, the author took a different shutter speed with the same ISO, which is 1600. The results obtained from the ISO settings are that many images are damaged, even more when compared to ISO 1600 with a shutter speed of 8s. The factors that allow this to happen are camera instability and ISO settings that are too high, so that indeed a lot of light enters but the image tends to be noisy because of the instability.

Unlike the ISO 800 and 1600 settings with shutter speeds of 8s and 10s. camera settings using ISO Auto and Shutter speed Auto have more stable graphics. This is in line with the function and purpose of the Auto setting, which is to provide convenience for users in getting good photo results without having to manually set each parameter. The author concludes that the stability obtained is

influenced by several factors, namely because ISO Auto and Shutter speed Auto can automatically adapt to light conditions so that the results obtained are more consistent and the algorithm used is also sophisticated to evaluate light conditions in real-time.

From here it can be understood that the different ISO and Shutter speed settings greatly affect the quality of dawn light. The higher the ISO used, the more noisy and irregular the resulting image will be. While the use of ISO Auto and Shutter speed Auto are the recommended camera settings. This is because the Auto setting has a sophisticated algorithm which can automatically adapt to light conditions so that the results obtained are more consistent and stable.

Then, if we process the data further using Accurate Time, the resulting data is as follows:

Table 2: Results of Dawn Image Data Processing

ISO	*Shutter speed*	Kemunculan cahaya fajar	Altitude
800	8	04:43:00 AM	-16:25:00
1600	8	04:42:00 AM	-16:39:19
1600	10	04:42:00 AM	-16:39:19
Auto	Auto	04:34:00 AM	-18:18:38

From the data above, it can be understood that the use of high ISO will detect the dawn light faster and the use of low ISO will be slower to detect the appearance of dawn light. As we see at ISO 800 the dawn light appears at 04:43 AM with a sun height of -16:25:00. In other words, the light sensor obtained when using ISO 800 will take longer to detect light. This can happen due to a lack of light sensitivity or a lack of light recorded in the image so that the light is still difficult to detect. While at ISO 1600 the dawn light appears at 04:42:00 AM with a sun height of -16:39:19. This shows that the use of ISO 1600 detects the appearance of dawn light faster, although only a difference of 1 minute but the use of this high ISO affects the speed of detecting dawn light. Then in the ISO Auto setting the dawn light is detected faster, namely 04:34:00 AM with a sun height of -18:18:38. In this case the use of ISO Auto is faster in detecting the intensity of dawn light. And it can be concluded that the ISO setting has an effect on the acquisition of dawn image data.

In the Shutter speed setting, if you look at the data above, there is no effect on the time of dawn and the height of the sun, this can be seen in the use of ISO 1600 with Shutter speed 8s and Shutter speed 10s having the same results. However, if you look at the graph, the use of this Shutter speed affects the image quality, on the graph you can see the curve with Shutter speed 10s is more messy or irregular compared to the use of Shutter speed 8s. that means the use of this Shutter speed affects the quality of the dawn image.

D. Conclusion

Based on observations and data processing that has been done, ISO and Shutter speed have an effect on the quality of dawn images. Manual settings with ISO 800 with Shutter speed 8s have a graph with a curve that is slightly out of line and ISO 800 is more or less in detecting the intensity of light entering the image. ISO 1600 with Shutter speed 10s and 8s has a very irregular graph, many photos are noisy so that many images are out of the curve. The results of observations of light intensity are faster when compared to ISO 800, this is because the higher the ISO, the higher the light sensitivity. Then the use of ISO Auto and Shutter speed Auto settings has a neat and stable graph, no images are out of the curve so this setting is what researchers recommend to further researchers who want to observe Dawn Light.

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