DEVELOPMENT OF ASTRO TIME ISLAMIC PRAYER SCHEDULE APPLICATION AND ALTITUDE CORRECTION TEST

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Abstract

The tool for calculating prayer times continues to develop. Likewise, there are several different formulas for calculating prayer times, both with the addition of altitude correction and without altitude correction. This article uses the prayer time formula which takes into account altitude corrections into an application called *Islamic Astro Time* which uses *Matlab* programming with solar data from the astronomical algorithms formula by Jean Meeus. This article is an experimental qualitative with descriptive analysis. This article finds that the calculation of prayer times in the *Islamic Astro Time* application using varying altitude levels results in different times. The difference in results starts from 2 minutes at a building height of 250 meters to more than 2 minutes depending on the level of height. The higher the position of the person praying, the greater the difference between the start of the prayer and the lower place. So that every Muslim who wants to pray must pay attention to the altitude correction factor with the sun's position approaching the horizon, namely the time of dawn, late dawn (*ṭulū'*), maghrib, and evening prayers.

Keywords: *prayer time, altitude correction, Islamic Astro Time*

Abstrak

Alat hitung waktu salat terus mengalami perkembangan. Begitu pula perhitungan waktu salat terdapat beberapa rumus yang berbeda, baik dengan penambahan koreksi ketinggian maupun tanpa koreksi ketinggian. Artikel ini menggunakan rumus waktu salat yang memperhitungkan koreksi ketinggian menjadi sebuah aplikasi yang bernama *Islamic Astro Time* yang menggunakan pemprograman matlab dengan data matahari dari rumus *astronomical algorithms* karya Jean Meeus. Artikel ini berupa kualitatif eksperimental dengan analisis deskritif. Artikel ini menemukan bahwa perhitungan waktu salat pada aplikasi *Islamic Astro Time* dengan menggunakan tingkat ketinggian yang bervariasi mendapatkan hasil waktu yang berbeda-beda. Selisih hasil tersebut mulai dari 2 minute pada ketinggian bangunan 250 meter hingga lebih dari 2 minute tergantung pada tingkat ketinggiannya. Semakin tinggi posisi orang salat, maka semakin besar selisih awal salat dengan tempat yang rendah. Sehingga setiap Muslim yang hendak melakukan salat harus memerhatikan faktor koreksi ketinggian dengan posisi matahari yang mendekati ufuk yakni waktu salat subuh, akhir subuh (*ṭulū'*), maghrib, dan isya.

Kata kunci: waktu salat, koreksi ketinggian, *Islamic Astro Time*

A. Introduction

Prayer is a direct command from Allah SWT to the Prophet Muhammad without going through the angel Gabriel. The order was given when the Prophet SAW made an incredible journey known as the Isra' Mi'raj event. Previously, every command of worship or the revelation of verses reached the Messenger of Allah through the intermediary of the angel Jibril alaihi salām. It shows that prayer is an essential commandment in Islam until parents receive orders to teach prayers to their children when the child is seven years old, and parents are allowed to hit their child if the child leaves the prayer when the child is ten years old. The Messenger of Allah said:

عَنْ عَمْرِو بْنِ شُعَيْبٍ، عَنْ أَبِيهِ، عَنْ جَدِّهِ، قَالَ قَالَ رَسُولُ اللَّهِ صلى الله عليه وسلم " مُرُوا أَوْلاَدَكُمْ بِالصَّلاَةِ وَهُمْ أَبْنَاءُ سَبْعِ سِنِينَ وَاضْرِبُوهُمْ عَلَيْهَا وَهُمْ أَبْنَاءُ عَشْرِ سِنِينَ وَفَرِّقُوا بَيْنَهُمْ فِي الْمَضَاجِعِ

> *"Narrated Abdullah ibn Amr ibn al-'As:The Messenger of Allah (ﷺ) said: Command your children to pray when they become seven years old, and beat them for it (prayer) when they become ten years old; and arrange their beds (to sleep) separately.."* (HR Daud).[1]

All Muslims as long as they are exposed to legal taklif, it is obligatory for Muslims to pray anywhere. However, the implementation of prayer has been regulated in terms of its performance and time. The procedure for performing prayers imitates the invocations

Prayer time is the time limit for Muslims to pray in it. So Muslims who want to pray must ensure that the prayer to be carried out must have entered its time because the time for prayer is one of the conditions for a valid prayer.

In the era of the Prophet Muhammad, prayer times were only shown as a natural phenomenon, and there are no details of the time as it is today. If the natural wonder in the form of the sun is disturbed by cloudiness or rain, so Muslims who want to pray will find it challenging to know the sun's existence, even though the determination of the beginning and end of time depends on the position of the sun.[2]

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[1] Abī Dāwud Sulaimān bin al-Asy'at Al-Sajastānī, *Sunan Abī Dāwud* (Riyadl: Maktabah al-Ma'ārif, n.d.), 91.

[2] Nashifatul Wadzifah, "Studi Analisis Metode Hisab Awal Waktu Salat Ahmad Ghozali dalam "Irsyad al-Murid"," *Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan* 2, no. 1 (2016): 46, https://doi.org/10.30596%2Fjam.v2i1.765.

The development of science and technology in all lines of human life positively impacts knowing the beginning of prayer times. Found formulas and tools for prayer times that can help find prayer times easily, even to get an accurate initial calculation of prayer. Applications have been found so that Muslims who want to pray quickly know the beginning of prayer times, but there are still many problems with many differences in the calculation of the birth of prayer times. Factors for the difference in the start of prayer times include considering the height of the place in calculating prayer times.

Given that places or regions in the world have different highlands and lowlands. Of course, this will affect the time of sunrise and sunset on the horizon. A cursory overview of prayer times related to the sun's position rising and setting, namely the time of Fajr and Maghrib.

B. Method

This type of research is qualitative through an experimental library approach—primary data using the Islamic Astro Time application. At the same time, secondary data comes from books, journals and writings related to prayer times. The results of the calculation of prayer times from the Islamic Astro Time application become the author's focus to analyze the effect of altitude on the difference in prayer times by using certain height variables.

C. Results and Discussion

C.1 Legal Basis and Formulation of Prayer Times

Prayer time is one of the topics of discussion in the treasures of astronomy. Terminologically, the word prayer comes from the Arabic language لَاةً لِّي لَّى. The word prayer and its deviation in the Qur'an has three meanings: first, prayer means ا means prayer. As the word of Allah SWT:

> *"Take from their wealth ˹O Prophet˺ charity to purify and bless them, and pray for them—surely your prayer is a source of comfort for them. And Allah is All-Hearing, All-Knowing.."* (Q.S. *Al-Taubah*/10: 103)[3]

[3] Kementerian Agama RI, *Al-Qur'an & Tafsirnya* , vol. 4 (Jakarta: Widya Cahaya, 2011), 198.

Second, salat means mercy or compassion; third, salat means ار means asking for forgiveness. As the word of Allah SWT:

> *"Indeed, Allah showers His blessings upon the Prophet, and His angels pray for him. O believers! Invoke Allah's blessings upon him, and salute him with worthy greetings of peace."* (Q.S. *Al-Ahzāb*/33: 56)[4]

Wahbah Al-Zuḥailī explained, "*Salat from Allah to His servants is a mercy, His angels are istighfar and from the Prophet and the believers is prayer.*"[5]Aḥmad Zaynuddīn Ibn 'Abd al- 'Azīz al-Mālībarī argues, "*Salat is a worship that contains special words and deeds that begins with takbiratul ihram and ends with greetings.*"[6]

The Qur'an, as the argument in the first order in Islam, has explained that the prayers that are obligatory for believers are carried out at a predetermined time, as stated in the letter al-Nisā' verse 103:

> *"When the prayers are over, remember Allah—whether you are standing, sitting, or lying down. But when you are secure, establish regular prayers. Indeed, performing prayers is a duty on the believers at the appointed times."* (Q.S. *Al-Nisā'*/4: 103)[7]

Jalāluddīn Al-Maḥallī, in his book *Tafsīr al-Jalālayn*, interprets the *mawqūtān* pronunciation (which is set in time) that the prayer time cannot be postponed or postponed. In contrast to Imam Wahbah Al-Zuhailī, explaining

> "*Prayer is an obligation whose execution time has been determined. It is not allowed to pray at a predetermined time, so you must perform the prayer at the specified time, both when travelling and in the area where you live or not travelling. The wisdom behind the determination of the five daily prayers so that a believer remembers his Lord during the day and night and periodically.*"[8]

Several verses in the Qur'an that explain prayer have yet to describe the beginning and end of prayer times in detail. The front and back of prayer times are presented in several hadiths of the Prophet Muhammad. One of the hadiths that explain prayer times is the hadith narrated by Jābir Ibn 'Abdullāh.

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[4] Kementerian Agama RI, *Al-Qur'an & Tafsirnya*, vol. 8 (Jakarta: Widya Cahaya, 2011), 37.

[5] Wahbah Al-Zuḥailī, *Tafsīr al-Munīr fī al-'Aqīdah wa al-Syarī'ah wa al-Manhaj*, vol. 6 (Beirut: Dār al-Fikr, 2003), 31.

[6] Aḥmad Zainuddin bin Abdul Azīz al-Mālībarī Al-Fannānī, *Fathul Mu'īn* (Beirut: Dār Ibni Hazm, 2004), 36.

[7] Kementerian Agama RI, *Al-Qur'an & Tafsirnya*, vol. 1 (Jakarta: Widya Cahaya, 2011), 252.

[8] Wahbah Al-Zuḥailī, *Tafsīr al-Munīr fī al-'Aqīdah wa al-Syarī'ah wa al-Manhaj*, vol. 3 (Beirut: Dār al-Fikr, 2003), 261.

أَخْبَرَنَا سُوَيْدُ بْنُ نَصْرٍ، قَالَ أَنْبَأَنَا عَبْدُ اللَّهِ بْنُ الْمُبَارَكِ، عَنْ حُسَيْنِ بْنِ عَلِيِّ بْنِ حُسَيْنٍ، قَالَ أَخْبَرَنِي وَهْبُ بْنُ كَيْسَانَ، قَالَ حَدَّثَنَا جَابِرُ بْنُ عَبْدِ اللَّهِ، قَالَ جَاءَ جِبْرِيلُ عَلَيْهِ السَّلاَمُ إِلَى النَّبِيِّ صلى الله عليه وسلم حِينَ زَالَتِ الشَّمْسُ فَقَالَ قُمْ يَا مُحَمَّدُ فَصَلِّ الظُّهْرَ حِينَ مَالَتِ الشَّمْسُ ثُمَّ مَكَثَ حَتَّى إِذَا كَانَ فَيْءُ الرَّجُلِ مِثْلَهُ جَاءَهُ لِلْعَصْرِ فَقَالَ قُمْ يَا مُحَمَّدُ فَصَلِّ الْعَصْرَ . ثُمَّ مَكَثَ حَتَّى إِذَا غَابَتِ الشَّمْسُ جَاءَهُ فَقَالَ قُمْ فَصَلِّ الْمَغْرِبَ فَقَامَ فَصَلاَّهَا حِينَ غَابَتِ الشَّمْسُ سَوَاءً ثُمَّ مَكَثَ حَتَّى إِذَا ذَهَبَ الشَّفَقُ جَاءَهُ فَقَالَ قُمْ فَصَلِّ الْعِشَاءَ . فَقَامَ فَصَلاَّهَا ثُمَّ جَاءَهُ حِينَ سَطَعَ الْفَجْرُ فِي الصُّبْحِ فَقَالَ قُمْ يَا مُحَمَّدُ فَصَلِّ . فَقَامَ فَصَلَّى الصُّبْحَ ثُمَّ جَاءَهُ مِنَ الْغَدِ حِينَ كَانَ فَيْءُ الرَّجُلِ مِثْلَهُ فَقَالَ قُمْ يَا مُحَمَّدُ فَصَلِّ . فَصَلَّى الظُّهْرَ ثُمَّ جَاءَهُ جِبْرِيلُ عَلَيْهِ السَّلاَمُ حِينَ كَانَ فَيْءُ الرَّجُلِ مِثْلَيْهِ فَقَالَ قُمْ يَا مُحَمَّدُ فَصَلِّ . فَصَلَّى الْعَصْرَ ثُمَّ جَاءَهُ لِلْمَغْرِبِ حِينَ غَابَتِ الشَّمْسُ وَقْتًا وَاحِدًا لَمْ يَزُلْ عَنْهُ فَقَالَ قُمْ فَصَلِّ . فَصَلَّى الْمَغْرِبَ ثُمَّ جَاءَهُ لِلْعِشَاءِ حِينَ ذَهَبَ ثُلُثُ اللَّيْلِ الأَوَّلُ فَقَالَ قُمْ فَصَلِّ . فَصَلَّى الْعِشَاءَ ثُمَّ جَاءَهُ لِلصُّبْحِ حِينَ أَسْفَرَ جِدًّا فَقَالَ قُمْ فَصَلِّ . فَصَلَّى الصُّبْحَ فَقَالَ " مَا بَيْنَ هَذَيْنِ وَقْتٌ كُلُّهُ

> *"Jābir Ibn 'Abdullāh said: "Jibril, peace be upon him, came to the Prophet (ﷺ) when the sun had passed its zenith and said: 'Get up, O Muhammad, and pray Zuhr when the sun has passed its zenith.' Then he waited until a man's shadow was equal to his height. Then he came to him for 'Asr and said: 'Get up, O Muhammad, and pray 'Asr.' Then he waited until the sunset, then he came to him and said: 'Get up, O Muhammad, and pray Maghrib.' So he got up and prayed it when the sun had set. Then he waited until the twilight disappeared, then he came to him and said: 'Get up, O Muhammad, and pray 'Isha'.' So he got up and prayed it. Then he came to him when dawn broke and said: 'Get up, O Muhammad, and pray.' So he got up and prayed Subh.' So he got up and prayed Subh. Then he came to him the next day when a man's shadow was equal to his height, and said: 'Get up, O Muhammad, and pray.' So he prayed Zuhr. Then Jibril came to him when a man's shadow was equal to twice his length and said: 'Get up, O Muhammad, and pray.' So he prayed 'Asr. Then he came to him for Maghrib when the sun set, at exactly the same time as the day before, and said: 'Get up, O Muhammad, and pray.' So he prayed Maghrib. Then he came to him for 'Isha' when the first third of the night had passed, and said: 'Get up and pray.' So he prayed 'Isha'. Then he came to him for Subh when it had become very*

bright, and said: 'Get up and pray.' So he prayed Subh. Then he said: 'The times of prayer one between those two (limits).'" " (al-Nasā'ī)[9]

Hadiths that explain the beginning and end of prayer times are based on natural phenomena, not clocks. It is the love of Allah SWT. Determination based on natural wonders is straightforward to apply in all parts of the earth that have different sunrise-sunset times. Of course, based on natural phenomena, it will be beneficial for those who don't have or know clocks.[10]

Prayer Times

Prayer times are critical with the implementation of prayer because knowing prayer times is a condition for the fourth prayer. Knowing the time to pray can be with certainty or prejudice. The prayers performed are considered invalid for the *muṣallī* who perform prayers without knowing the time for prayer.[11]

The time for the Zuhur prayer is the time whose initial time is marked by the sun's slipping to the west after the sun at its culmination point. This prayer time is called Zuhur because it is the first prayer that appears to be performed in Islam. Al-Nawāwī argues, "*It is called the noon prayer because actually, this prayer is visible in the middle of the day*".

Indeterminate mid-time shows 12.00, sometimes more or less than 12.00, depending on the value of the Equation of time (e). Thus, the mid-time when the sun is in the meridian pass can be determined by the formula MP = 12-e; shortly after this time was the beginning of Zuhur time according to the middle time, and this time was the basis for calculating other prayer times. The end of the Zuhur prayer time is marked by the shadow of an object that has the length of the thing at its culmination. [12]

Asr prayer time is a prayer time whose beginning is marked by the end of Zuhur time. A hadith narrated by Ibn ʻAbbās explains:

[9] Abī 'Abdul Raḥman Aḥmad Syu'aib bin 'Alī Al-Nasāī, *Sunan al-Nasāī* (Riyadl: Maktabah al-Ma'ārif, n.d.), 87.

[10] Jayusman, "Akurasi Nilai Waktu Ihtiyath dalam Perhitungan Awal Waktu Salat," *Asas : Junal Hukum Ekonomi Syari'ah* 11, no. 1 (2019): 82, https://doi.org/10.24042/asas.v11i01.4644.

[11] Al-Fannānī, *Fathul Mu'īn*, 87.

[12] Abī 'Abdillah Syamsuddin Muḥammad bin Qāsim bin Muḥammad Al-Gazīy, *Fatḥu al-Qarīb al-Mujīb fī Syarḥi al-Fāẓi al-Taqrīb au al-Qaul al-Mukhtār fī Syarḥi Gāyah al-Ikhtiṣār* (Beirut: Dār Ibni Ḥazm, 2005), 66.

> "That the Messenger of Allah performed the Asr prayer when the shadow of everything was as long as that thing, tomorrow, the Messenger of Allah prayed the Asr prayer when the shadow of the object was twice the length of the object."

Then made a compromise that the Messenger of Allah performed the Asr prayer when the shadow of an object was one time long when there was no shadow of the sun at its culmination. Meanwhile, the Messenger of Allah performed the Asr prayer when the shadow formed twice the object's length when at the sun's conclusion, the thing had a shadow equal to the object's size. Therefore, the position of the sun or position at the initial part of the Asr time is calculated from the horizon along the vertical circle (has) formulated: Cotan has = tan [ϕ - 0] + 1. It is called the Asr prayer because it is performed near Maghrib's time. End of Asr time with sunset.[13].

Maghrib time is also known as sunset time. It was the beginning of Maghrib time, with the sun setting on the western horizon. The sun is said to select according to the eye view of the mushalli. In Al Umm, Imam Al-Syafī says that the Maghrib prayer begins at sunset. The indicator for the sun's setting is that the entire sun disk is invisible to the eye. According to the opinion of the Shafi'i scholars, to know the perfect set of the sun can be seen when observed in the desert. The ideal sunset indicator for urban areas and mountains is when there is no sunlight on the walls and hills. In the east, it starts to get dark. Furthermore, the Shi'ites think that the beginning of the time for the Maghrib prayer begins when the stars in the sky are visible. From this opinion, it is the same as the agreement of the scholars regarding the start of the Maghrib time at the time of the total sunset.[14]

Calculating the position of the celestial bodies originates in the analysis of the sun's centre point calculated from the earth's centre. Therefore in calculating the part of the sunset, it is necessary to include the Horizontal Parallax of the Sun, the Lowness of the horizon or Dip, the Refraction of light and the Semidiameter of the Sun. It's just because the Parallax of the Sun is too small in value, around 00° 00' 8" so that the Parallax of the Sun in the sunset

[13] Al-Gazīy, *Fatḥu al-Qarīb al-Mujīb fī Syarḥi al-Fāẓi al-Taqrīb au al-Qaul al-Mukhtār fī Syarḥi Gāyah al-Ikhtiṣār*, 67.

[14] M Ihtirozun Ni'am dan Khabib Suraya, "Analemma and The Beginning of Maghrib Prayer Alteration (Correlation ff Analemma's Position Towards The Beginning of Maghrib Prayer According To Ephemeris Calculation)," *Al-Hilal: Journal of Islamic Astronomy* 3, no. 1 (2021): 36, https://doi.org/10.21580/al-hilal.2021.3.1.7649.

time calculation can be ignored. So that the beginning of Maghrib time by calculating the sun's height from the horizon along the vertical circle (HMG) is formulated as follows: :

Horizon	(SD + Refraction + Dip)
SD	0° 16' 00"
Refraction	0° 34' 30"
Dip	0° 1,76' x √place height (m).[15]

Isha's time begins with the sinking of the red mega. It is called isya 'because the prayer is performed at the beginning of the night. The reckoning experts assume that at that time, the sun was about -18° from the western horizon. Some other opinions ranged from -15° to -17.5°. Meanwhile, according to Abū Ḥanīfah, "*the beginning of the time of Isha the loss of white light*," namely, the height of the sun is about -19 °. According to most scholars, "*the end of Isha' is the entry of Fajr time*." Some scholars think "*the end of Isha's time is midnight*." Some argue that the end of Isha's time is a third of the night. The formula for determining the time of Isha 'that is, with the position or height of the sun, is as follows:

$h_{isya'}$	(SD + Refraction + Dip)
SD	0° 16' 00"
Refraction	0° 3'
Dip	0° 1,76' x √tinggi tempat (meter)

Imsak time is the time used as the deadline for eating sahur for people who will fast during the day. The time of Imsak is a precautionary measure so that people who do fasting do not exceed the starting time limit, namely the beginning of Fajr time. As the Prophet's Hadith narrated from Zaid bin Thabit: "We had sahur with the Messenger of Allah. Then the Fajr prayer. and between the time of dawn and the time of Fajr, there is an interval of about 50 verses (reading 50 verses of the Qur'an) ". The time needed to read 50 verses of the Qur'an is about 10 minutes, so the time of Imsak occurs 10 minutes before dawn.

Fajr time begins with sunrise *ṣādiq*. Dawn *ṣādiq*, or the second dawn, is a light that spreads across the horizon. While the first dawn, called the start of kā ib, is a reddish light that appears and then blackens or disappears. The morning of commencement is brighter than the light of dusk, as evidenced by the sun's position at about -20° on the eastern horizon. It

[15] Khazin, *Ilmu Falak dalam Teori dan Praktik*, 90.

begins to dim the light of the stars. The height of the sun at the beginning of the dawn (hsb) is as follows:

h_{subuh}	(SD + Refraction + Dip)
SD	0° 16' 00"
Refraction	0° 3'
Dip	0° 1,76' x √place height (m)

A tangent marks the time of sunrise, or what is meant by daylight to the upper sun's disk with the eastern horizon, and then the provisions that apply at Maghrib time also apply to the time the sun rises. So, the sun's height at sunrise is h = -1°.[16]

The beginning of Duha time when the sun is as high as a spear. In astronomy, the early Duha prayer time can be formulated as the arc distance along the vertical circle from the horizon to the sun's position, which is 4°30'. Therefore h = 4° 30'.[17]

Prayer Time Instruments

The positive impact of the development of technology and information can be felt in various lines of human life, including the development of calculating tools used to calculate prayer times. Here's a calculator that can use to calculate prayer times:

a. *Rubu' Mujayyab*

Rubu' mujayyab (astrolabe quadrant) is a calculation tool with a quarter circle shape with geometric calculations. This tool is usually made of wood or boards in the form of a quarter circle. The surface of the rubu 'mujayyab has a design in the form of lines with a particular scale. Rubu 'mujayyab is equipped with counting angles (sin, cos and tan) so that rubu' mujayyab can be used to calculate prayer times. In addition, rubu 'mujayyab can also function to determine the direction of Qibla, the four cardinal directions. For engineers, rubu 'mujayyab can help in their work to find out the height of the building and the depth of the well.[18]

b. Calculator

A calculator is an electronic device that can use to calculate mathematical operations in a short amount of time. Calculators are easier to use than

[16] Kementerian Agama RI, *Ephemeris 2022*, 2022, 417. Khazin, *Ilmu Falak dalam Teori dan Praktik*, 94.
[17] Izzuddin, *Ilmu Falak Praktis Metode Hisab Rukyat Praktis dan Solusi Permasalahannya*, 90.
[18] *Tibyān al-Mīqāt fī Ma'rifat al-Auqāt al-Qiblah* (Kediri: Madrasah Salafiyah al-Falah, n.d.), 40.

computers. Calculators can help people who have trouble counting. In general, calculators are divided into two types. First, the ordinary calculator that traders usually use to calculate their wares. The features and appearance of a regular calculator are simple and limited to addition, subtraction, multiplication and division. Second, a scientific calculator is used to perform complex mathematical operations, often used in scientific and engineering applications. The calculator has full features and is designed to help people solve calculations in various fields, including astronomy, such as the Qibla direction, the Qibla direction lunar calendar and the eclipse.

Prayer Time Digital Instrument

The prayer times application is the latest calculation tool. There have been many applications for prayer times since many people use communication tools like smartphones. Most of the prayer time applications are based on windows and android. The Windows base is used on computers and laptops, while gadgets or smartphones use the Android command. The prayer time application makes it easy for users to know about prayer times with precision, accuracy and practicality. Smartphones are easy to carry everywhere by simply placing them in a bag or a shirt pocket equipped with advanced features such as GPS and internet. In some prayer times, applications have been fitted with a Qibla direction compass, lunar year calendar, and eclipses such as digital astronomy.[19].

Altitude correction

Place height is the vertical distance from the horizon or sea level to the height of the place. The site's height is calculated from sea level, whether it has a highland or hilly texture, so the height of the zone uses units of meters or MdPL (meters above sea level). The altitude data can be obtained using an altitude meter (altimeter) and a global positioning system (GPS).[20]

[19] "Aplikasi Digital Falak," diakses 10 April 2022, https://play.google.com/store/apps/details?id=com.digital.falak&hl=in&gl=US .

[20] Sub Direktoral Pembinaan Syariah dan hisab Rukyat Kementerian Agama RI, *Buku Saku Hisab Rukyat*, 2013, 67.Ahmad Mushonnif, *Ilmu Falak: Metode Hisab Awal Waktu Salat, Arah Kiblat, Hisab Urfi dan Hakiki Awal Bulan,* (Yogyakarta: Teras, 2011), 70.

Each place has different highs and lows. In calculating the initial prayer time, the height of the area becomes one factor affecting the results of the calculation of the initial prayer time. It happens because it has something to do with the difference between the horizon's lowness and the sun's height. Then it will form a different time angle as well. The height of the place is needed to know the lowness of the horizon (Ku). The formula for the low of the horizon (Uk) = 0° 1.76' m (m= height of place).[21]

The lowness of the horizon indicates that something seen on the horizon does not necessarily have a distance of 90° from the zenith point, but the horizon that the distance from the zenith to the observer depends on the height of the place where the observer is. The horizon is called the mar'i horizon. A place that is in the highlands, then that place has a lower horizon, meaning that between the zenith and the horizon is more than 90°.

The place's height is one factor in the difference at the beginning of prayer times. When the sun sets on the horizon, it will form a different point of view between the highlands and lowlands. If you can still see the sunset process in a highland area, then the sun has set in a lowland area. The lowlands will enter the Maghrib prayer time faster than the highlands. The same applies to entering the time for the Fajr prayer, which is based on the dawn of Sadiq.[22]

Thomas Djamaluddin's view, correction for highland areas, such as Bandung (768 meters above sea level), does not need correction for highland elevation. The reason, continued Thomas, is that the height of the flat area only adds to the divisor factor in Formula 1, becoming R+t if t is the height of the plain from sea level. The value of t is too small and can be ignored when compared to the earth's radius R. Thus, the elevation of the highlands is equated with the rest of the earth's relatively flat surface. In conclusion, the height correction formula only applies to skyscrapers.[23]

In addition to the elevation correction on the "Skyscraper", there are also terrains that need correction, with some exceptional cases to be explicitly calculated:

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[21] Sub Direktoral Pembinaan Syariah dan hisab Rukyat Kementerian Agama RI, *Buku Saku Hisab Rukyat*, 82.

[22] Muhamad Abdulah, M Roji Iskandar, dan Ramdan Fawzi, "Penentuan Awal Waktu Salat Maghrib dikaitkan Ketinggian Dataran Suatu Daerah," *Prosiding* 2, no. 2 (2016): 50, https://doi.org/10.29313/islamic%20family.v0i0.3422.

[23] https://tdjamaluddin.wordpress.com/2015/07/10/kapankah-koreksi-ketinggian-diterapkan-pada-jadwal-salat/ diakses pada tanggal 30 September 2022 pukul 13.36 WIB.

- When we are on the valley's edge facing the western horizon, the Maghrib time correction applies. The height of the place calculated is the height of the hill relative to the flat area below it (e.g. the open sea). We see the sun setting slower at that position because the horizon is getting lower. If below it is not plains, but hills, do not use elevation correction.
- If there is a high hill that makes the horizon higher on the western horizon, then Maghrib will be faster. Likewise, if on the eastern horizon, there is a hill that causes the horizon to be higher, the time for Fajr will be slower. In such a case, the correction of the prayer schedule cannot use the general formula. Please use the estimated *iḥtiyāṭ* (cautionary) correction.

In its use, Jamaluddin said that if the prayer schedule is used for the general public, then the basic assumption is used, so there is no horizon correction here. However, if the prayer schedule is used in a particular area, it is modified according to the empirical elevation data for that area.[24]

C.2 "Islamic Astro Time" Applicstion Design

The author designed a prayer time application equipped with a high place. This application is based on the Matlab programming language. The author develops this application by entering the location coordinates and the prayer time formula. Here are the steps for making the Islamic Astro Time application:

a. Input coordinate:

   This application can enter coordinate data with two events. First, the manual method means entering the coordinates of a city one by one so that the user can determine the coordinates as desired. Second, the automatic way. This method is relatively easy for users because by selecting the coordinates of the city or district where the user is located, the coordinates will automatically appear. Coordinate data intuitively, the author obtained from the BMKG website in Microsoft Excel format.

b. Sun data inputting

[24] Imam Baihaqi, *Analisis Sistem Perhitungan Awal Waktu Salat Thomas Djamaluddin*, (Skripsi UIN Walisongo: Semarang, 2017). 93

The Sun's Declination and Equation of Time are the solar data needed in calculating prayer times. Both use the calculations of Jean Meeus from the book Astronomical Algorithms. Here are the steps to get the Sun's Declination and Equation of Time values:

1) Julian Day calculation:

Julian Day (JD) is the number of days that have passed since January 1, 4713 BC (BC) at 12:00:00 UT (Universal Time) or midday. By calculation, the year 4713 BC is the same as the year –4712.

- JD 0 = 1 January –4712 12:00:00 UT = 1,5 January–4712
- JD 0,5 = 2 January –4712 00:00:00 UT
- JD 1 = 2,5 January –4712.
- 4 October 1582 M = JD 2299159,5
- 15 October 1582 M = JD 2299160,5

Steps:

a) Enter numeric data in the form Hour (H), Date (D), Month (M) Year (Y) and Time Zone (TZ).

b) Calculate the Value of A and B as follow:

A = INT (y/100)

B = 2-A+ INT (A/4)

c) Calculate Julian Day JD

After calculating the Julian Day (JD) then calculate the value of the Sun's Declination and Equation of time with several formulas:

JD = INT (365.25 x (y + 4716)) + INT (30.6001 x (m+1) + D + J/24 + B – 1524.5 – ZW/24[25]

a) Calculate the value of T

T = (JD-2451545)/36525[26]

b) Calculate the value of M (*Mean Anomaly of the Sun*)

[25] Jean Meeus, *Astronomical Algorithms*, *Choice Reviews Online*, I, vol. 30 (Virginia: Willman Bell, 1991), 61.

[26] Jean Meeus, 151. Meeus, 3:151.

$M = 357^{o}52910 + 3599^{o},05030 \times T - 0^{o}0001559 \times T^{2} - 0^{o},000000048 \times T^{3}$

c) Calculate the the eccentricity of the Earth's orbit

$e = 0.016708617 - 0.000042037 \times T - 0.0000001236 \times T^{2}$

d) Calculate Sun's formula:

$C = +(1^{o}.914600 - 0.004817 \times T - 0.000014\ T^{2}) \times \sin M + (0.019993 - 0.000101 \times T) \times \sin 2M + 0.000290 \times \sin 3M$ [27]

e) Calculate the value of L_o (*Geometri Mean Longitude of the Sun*)

$L_o = 280.46645 + 36000.76983 \times T\ 0.0003032 \times T$[28]

f) Calculate the pure Sun longitude

$\Theta = L_o + C$ [29]

g) Pure Sun Anomaly

$v = M + C$

h) Calculate the value of ε (*Mean Obliquity of the Ecliptic*)

$\varepsilon = 23^{o}\ 26\ 21.448" - 0^{o}\ 0'\ 4680.93" \times U - 0^{o}\ 0'$ 1,.55" $\times U^{2} + 0^{o}\ 0'\ 1999.25" \times U^{3} - 0^{o}\ 0'\ 51.38" \times U^{4} - 0^{o}\ 0'\ 249.67" \times U^{5} - 0^{o}\ 0'\ 39.05" \times U^{6} = 0^{o}\ 0'\ 7.12" \times U^{7} + 0^{o}\ 0'\ 27.87" \times U^{8} + 0^{o}\ 0'$ 5.79" $\times U^{9} + 0^{o}\ 0'\ 2.45" \times U^{10}$ [30]

i) Determine Sun Declination δ'

$\sin \delta' = \sin \varepsilon \times \sin \Theta$ [31]

j) Determining λ (*Apparent Longitude of the Sun*)

$\lambda = \Theta - 0.00569 - 0.0047 \times \sin (125.04 - 1934.136 \times T)$[32]

Because the value of the declination of the sun and the Equation of time is constantly changing from time to time, the author uses certain hours to collect the sun's declination data and this Equation of time. Therefore, for the value of the declination of the sun and the Equation of time, the authors use the following

[27] Jean Meeus, 151-152. Meeus, 3:151.
[28] Jean Meeus, 151.
[29] Jean Meeus, 151.
[30] Jean Meeus, 151-152.
[31] Jean Meeus, 153
[32] Rumus yang diformulikan ulang oleh Rinto Anugraha yang bersumber dari Jean Meeus. Lihat Anugraha, *Mekanika Benda Langit*, 89.

reference hours: Fajr = 04.00 LMT, Rise = 05.30 LMT, Duha = 06.00 LMT, Zuhur = 12.00 LMT, Asar 15.00 LMT, Magrib 17.30 LMT, Isha = 19.00 LMT.

C.3 Reviewing the "Islamic Astro Time" Application

The research study on the design of the prayer time program has a product accuracy process that will be disseminated as a form of responsibility for the research. In testing the accuracy of the results of the calculation of prayer times on the IslamicAstro Time application, it is carried out to see whether this application is correct or whether there are still errors. It is testing this prayer schedule application using the location of the Burj Khalifa Building with coordinates of 25' 11' 48" North Latitude and 55' 16' 22" East Longitude with +3 time zone on September 28, 2022.

Testing for an altitude of 0 masl and 250 masl

The author tested at an altitude of 0 masl and 250 masl to get a difference of 2 minutes of prayer time at the time of Maghrib, Isha, and Fajr prayers. The comparison results in table 1 show that the difference in the calculation of Islamic Astro Time for prayer times with a difference of 2 minutes is influenced by the low value of the horizon.

Table 1 : Comparison of Prayer Times on September 28, 2022 altitude 0 masl and 250 masl

No	Prayer Time	0 m	250 m	Gap
1	Zuhur	11:13 LMT	11:13 LMT	0 minute
2	Asar	14:37 LMT	14:34 LMT	0 minute
3	Magrib	17:12 LMT	17:14 LMT	2 minutes
4	Isya'	18:27 LMT	18:29 LMT	2 minutes
5	Imsak	03:38 LMT	03:38 LMT	2 minutes
6	Subuh	03:48 LMT	03:48 LMT	2 minutes
7	Terbit	05:08 LMT	05:06 LMT	2 minutes
8	Dhuha	05:36 LMT	05:36 LMT	0 minute

For the second test, the author uses a height of 500 m above sea level to compare the first test with an interval of 250 m. The test results in table 2 show the value of numbers 3 and -3, which means that the difference between the altitude of 0 masl and 500 masl is a difference of 3 minutes. Only a 1-minute difference from a height of 250 meters above sea level. There is a specific point from the two tests. At an altitude of 0 masl - 250 masl, there is a difference of 2 minutes. At the same time, 250 masl - 500 masl get the result of a difference of 1 minute. The "altitude" value, which uses meters (m), is entered into the formula for low horizon (Ku) rooted and multiplied by 0°1.76'.

Table 2 : Comparison of Prayer Times on September 28, 2022 on 0 masl and 500 masl

No	Prayer Time	0 m	500 m	Gap
1	Zuhur	11:13 LMT	11:13 LMT	0 minute
2	Asar	14:37 LMT	14:37 LMT	0 minute
3	Magrib	17:12 LMT	17:15 LMT	3 minutes
4	Isya'	18:27 LMT	18:30 LMT	3 minutes
5	Imsak	03:38 LMT	03:35 LMT	-3 minutes
6	Subuh	03:48 LMT	03:45 LMT	-3 minutes
7	Terbit	05:08 LMT	05:05 LMT	-3 minutes
8	Dhuha	05:36 LMT	05:36 LMT	0 minute

The test data above shows that the influence of the height of the place during prayer times with the position of the sun below the horizon is Maghrib, Isha', Imsak, Fajr and Rising because the size of the area affects the lowness of the horizon. While the height of the site does not affect the time of prayer with the position of the sun above the horizon, namely the time of Zuhur, Asr and Dhuha.

In the test with a height of 250 masl, the difference in prayer times is 2 minutes, while at an altitude of 500 masl, the difference in prayer times is 3 minutes. The difference in time there is also an exciting thing before past midnight; the first time entered is a lower place. Meanwhile, after midnight prayer times (Imsak, Fajr, and Imsak), first, enter a higher position. This test shows that the more an area has a higher ground, the more significant the difference between the beginning of the prayer and the low setting. Of course, the influence of the height of the place must be considered and is very important, especially about breaking the fast, especially iftar in the month of Ramadan.

D. Conclusion

Prayer times are calculated by observing the factors that can affect the calculation of prayer times, including the height of the place, before using the Islamic Astro Time application to test the effect of altitude correction. First, the author conducted an accuracy test on the Islamic Astro Time application to check the accuracy of the Islamic Astro Time application with prayer times based on the website owned by the Islamic Guidance of the Ministry of Religion of the Republic of Indonesia. Data on the Islamic Astro Time application can be entered manually and automatically. So the authors take advantage of the manual feature to test the effect of altitude correction on the results of prayer times. Generally, the height correction in calculating prayer times is applied to skyscrapers. While we can use altitude correction in highlands, specific provisions must be considered, as stated by Thomas Djamaluddin regarding the altitude correction test.

Based on the test results of the effect of altitude correction at prayer times, the Islamic Astro Time application using the Burj Khalifa building and several different height variables. The author found a difference in these results, ranging from 2 minutes at a building height of 250 meters to more than 2 minutes, depending on the elevation level. The more mushalli or praying people are in a high place, especially in a skyscraper, the more significant the difference

between the beginning of prayer and a low place. So that the altitude correction factor must be considered by Muslims who want to pray with the position of the sun approaching the horizon, namely the time for the dawn prayer, the end of the dawn (thulu'), maghrib, and isya'.

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