ANALYSIS OF TIME-ZONE RELATIONSHIP TO EPHEMERIS DATA RETRIEVAL IN CALCULATING THE BEGINNING OF JEMBRANA-BANYUWANGI PRAYER TIMES

Agus Setya,[1] Youla Afifah Azkarrula,[2]*
[1]Bale Bet Malahayati Tabanan, Bali-Indonesia
*corresponding author: youlaafifahrvvl@gmail.com

Abstract

The calculation of prayer times in Bali and Banyuwangi Regency often needs to be clarified. Hasib suggests Bali's prayer time calculations could refer to those in Banyuwangi due to their close astronomical coordinates. While Bali uses the Central Indonesian Time Zone (WITA, GMT+8), Banyuwangi adopts the Western Indonesian Time Zone (WIB, GMT+7). This discrepancy arises despite the proximity of their locations, reflecting government decisions based on international considerations, especially after Bali was reassigned from WIB to WITA through Presidential Decree No. 41 of 1987. This library research uses qualitative methods such as documentation and descriptive analysis. It shows that the differences in prayer time calculations between Bali and Banyuwangi are minimal, often just a matter of seconds, mainly if there is an error in inputting Ephemeris data. However, such errors have no significant impact as long as the date remains consistent and time zone corrections adhere to official regulations.

Keywords*: Bali-Banyuwangi; Ephemeris Data; Prayer Time; Time Zone*

Abstrak

Perhitungan awal waktu salat di Bali dan Kabupaten Banyuwangi sering membingungkan. Hasib berpendapat bahwa perhitungan di Bali dapat merujuk pada Banyuwangi karena kedekatan koordinat astronomisnya. Bali menggunakan zona waktu WITA (+8), sementara Banyuwangi memakai WIB (+7). Sebelum Keppres No. 41 Tahun 1987, Bali termasuk zona WIB. Meski koordinat kedua wilayah berdekatan, mereka berada di zona waktu berbeda, sesuai keputusan pemerintah yang mempertimbangkan hubungan internasional. Penelitian ini bersifat kepustakaan dengan metode dokumentasi dan analisis deskriptif. Perbedaan perhitungan awal waktu salat Bali dan Banyuwangi hanya berkisar dalam hitungan detik jika terjadi kesalahan input data Ephemeris oleh hasib. Namun, kesalahan tersebut tidak berdampak signifikan asalkan data tetap berada pada tanggal yang sama dan zona waktu yang digunakan sesuai koreksi waktu daerah berdasarkan Keppres No. 41 Tahun 1987.

Keywords*: Bali-Banyuwangi; Data Ephemeris; Waktu Salat; Zona Waktu*

A. Introduction

Prayer is a *mu'aqqat* worship with set times that cannot be performed at any time. Prayer must be timed according to the evidence. The times of prayer are detailed in the Qur'anic texts and hadiths.[1] The Hadith, narrated by Jabir bin Abdullah r.a., has been explained the times to pray. From Zuhr time, which begins when the Sun starts to slip from the middle of the sky's meridian until the rise of Fajar Shadiq, which marks the beginning of the morning prayer time. Thus, it can be seen that to determine the time of prayer, Muslims use the position of the Sun as a benchmark for entering the beginning of the prayer time.[2]

To facilitate the determination of the beginning of prayer time, previous scholars and Islamic astronomy experts have converted the natural signs described as markers of the beginning of prayer time into a formula that will produce time in the form of hours. Experts will need solar data in its calculation, which can be obtained easily from the Indonesian Ministry of Religious Affairs's Ephemeris data. The data used will be determined by the location's time zone to be calculated. This time zone is referred to as taking solar Ephemeris data.

Indonesia has three time zones: western (WIB), central (WITA), and eastern (WIT). The division of these time zones is contained in Presidential Decree No. 41 of 1987, which effectively took effect on January 1, 1988.[3] Although this division is clear, some people still need to distinguish between the prayer time in Banyuwangi and Jembrana, especially people on the ship who travel this way. They need clarification about when they should go pray, stop eating for fasting (which is tied to Fajr and Imsak), and iftar (which is related to Maghrib). Furthermore, in the middle of the sea, the phone's GPS signal and data volume only sometimes work. Moreover, unfortunately, the crews on Banyuwangi-Jembrana ships do not inform the passengers when it is time to pray Fajr and other times prayer. This is underlying the fact that misunderstandings persist among travelers and lead to incorrect prayer times and fasting (have strong ties to prayer times) observances.

---

[1] Hasna Tuddar Putri, "Relevance of Hijri Clock as a System of Determining the Time of Worship," *Tharwah Journal of Islamic Civilization and Thought* 1, no. 2 (2021), doi:10.47766/tharwah.v1i2.12.

[2] Nur Qomariyah, "Penentuan Awal Waktu Salat (Awal Waktu Salat Asar, Magrib, dan Isya Berdasarkan Hadis Nabi)," *Al-Afaq: Jurnal Ilmu Falak dan Astronomi*, 2021, doi:10.20414/afaq.v2i2.2918.

[3] "Keputusan Presiden (Keppres) Nomor 41 Tahun 1987 Tentang Pembagian Wilayah Republik Indonesia Menjadi 3 (Tiga) Wilayah Waktu" (1987).

Some mistakenly take the GMT+7 as the general time zone in this problem-solving, even though they have arrived in the GMT+8 line. In addition, the Bali area is often equated with the Banyuwangi area, especially the Jembrana district of Bali, because of its proximity to Banyuwangi. Banyuwangi Regency is located at coordinates 7° 43' N - 8° 46' N and 113° 53' E - 114° 38' E.[4] Meanwhile, Jembrana Regency is located at the coordinates of 08° 09' 58“ S - 08° 28‘ 02” S and 114° 26' 28“ E - 115° 51’ 28” E.[5]

However, based on the Presidential Decree, Bali is included in the Central Indonesian time zone (WITA). This time zone difference will have an impact on ephemeris data collection. This impact could shift the time to when it should be. This causes the author to worry about the output obtained.

Based on the search, the author has yet to find a paper that discusses the time zone analysis of data collection at the beginning of prayer time in Bali and Banyuwangi. Ahmad Junaidi's article focuses on the ideal time zone for Indonesia and its relation to working hours.[6] Another article by Nailur Rahmi concluded that the determination of the beginning of prayer time remains based on the provisions contained in the text, namely the Qur'an and Hadith.[7]

The article by A. Frangky Soleiman discusses the times of prayer based on the Hadith narrated by Ahmad, an-Nasa'i, and Turmudzi from Jabir bin Abdullah ra. and focuses on civil twilight, nautical twilight, and astronomical twilight.[8] Dahlia Haliah Ma'u's dissertation discusses the level of accuracy of the conversion system in all-time prayer schedules circulating in Indonesia. It formulates the latitude limits of places that can convert all-time prayer schedules.[9]

These articles and dissertations need to discuss the effect of time zones on ephemeris data collection in depth. In addition, this research is classified as very

[4] BPS Banyuwangi, *Kabupaten Banyuwangi dalam Angka 2023* (Banyuwangi: BPS Kabupaten Banyuwangi, 2023), 3.

[5] Nasehat Tono Amboro and Surya Hanggea Saptari, *Provinsi Bali dalam Angka 2023* (Bali: BPS Provinsi Bali, 2023), 11.

[6] Ahmad Junaidi, “Penyatuan Zona Waktu Indonesia dan Implikasinya Pada Waktu Ibadah,” *Justicia Islamica* 9, no. 2 (2012), doi:10.21154/justicia.v9i2.350.

[7] Nailur Rahmi, “Penyatuan Zona Waktu dan Pengaruhnya terhadap Penetapan Awal Waktu Shalat,” *Juris* 13, no. 1 (2014): 75–83, doi:10.31958/juris.v13i1.1130.

[8] Frangky Suleman, “Penentuan Awal Waktu Shalat,” *Jurnal Ilmiah Al-Syir’ah* 9, no. 2 (2016), doi:10.30984/as.v9i2.31, 13.

[9] Dahlia Haliah Ma’u, “Jadwal Salat Sepanjang Masa di Indonesia (Studi Akurasi Dan Batas Perbedaan Lintang Dalam Konversi Jadwal Salat)” (IAIN Semarang, 2013), 30.

old, so the latest research on time zones is needed. This research is required to investigate the impact of time zone differences on the accuracy of ephemeris data in determining prayer times, especially in regions close to time zone boundaries like Banyuwangi and Jembrana. Then, it could clarify the distinctions between the time zones, how they affect religious observances such as prayer and fasting times, analyze how misinterpretations in time zone application can affect ephemeris data and, consequently, spiritual practices such as Fajr, Imsak, and Maghrib in this context.

If this research is not conducted, people will continue miscalculating prayer times, particularly while crossing time zones. This could lead to improper observance of prayers and fasting, essential religious obligations. Therefore, the author is interested in examining the provisions for determining the Indonesian time zone and the effect of WIB and WITA time zones on ephemeris data collection in determining the beginning of prayer time in Jembrana-Bali Regency and Banyuwangi Regency.

B. Method

In this article, the author uses library research with qualitative data presentation. This research focuses on calculating the beginning of prayer time using ephemeris data by examining the effect of ephemeris data collection on two time zones. The locus of this research is the western Indonesian zone, namely Banyuwangi Regency in East Java, and the central Indonesian zone, namely Jembrana Regency in Bali. The data collection method used is the documentation technique. The primary data in this study is the Sun Ephemeris data published by the Indonesian Ministry of Religious Affairs; this research uses descriptive analysis techniques to obtain in-depth analysis and draw conclusions.

C. Result and Discussion

1. Indonesian Time Zone

The history of time zone designation in Indonesia dates back to the Dutch colonial period. To be precise, when the enactment of a regulation of *government Besluits.*[10] It officially took effect on May 1, 1908, and only applies to Java and

[10] Gouvernments Besluits are decrees of the Dutch East Indies government.

Madura; outside of that, the government does not regulate it. The Staats Sporwegen (Railway Ministry) then asked the government to arrange a time zone (*mintakad*) for smooth train travel in Java. Thus, the Dutch East Indies had set the Central Java region as Indonesia's zero point with GMT + 7:12.

On February 22, 1918, the regions of West Sumatra, East Sumatra, and Balikpapan became the first areas outside Java to get time sharing. Padang was recorded to have a time difference of 39 minutes later than Central Java. Meanwhile, Balikpapan is earlier than GMT, which is + 8:20.[11] Furthermore, there was a change in regulations on January 1, 1924. The regulation was changed by a regional ruler named *Hoofden Van Gewestelijk Bestuur in de Buitengewesten*. Hoofden set the time difference between Central Java and Greenwich to 7 hours and 20 minutes. Meanwhile, the time for the Karesidenan areas of Bali and Lombok is about + 22 minutes from Central Java. The time for Makassar is + 38 minutes from Central Java. Tapanuli is 45 minutes away from Central Java. Finally, the time in Padang is 7 minutes from Central Java.[12]

The fourth change occurred in 1932 when the Dutch divided the Indonesian archipelago into six time zones with a difference of 30 minutes per zone. In 1942, the fifth change was made during the Japanese occupation. According to Didi Kwartanada, a National University of Singapore historian, this change was made for the effectiveness of military operations and the organization of the Japanese occupation area in Asia. Indonesian time was determined to follow Tokyo time (GMT +9), so Java time advanced by 1:30 or GMT +7:30.

On December 10, 1947, the Colonial Government made the sixth change. During this time, the time zones in Indonesia were divided into three: GMT +7 at 105° longitude, GMT +8 at 120° longitude, and GMT +9 at 135° longitude. However, on May 1, 1950, the President of Indonesia made the seventh change by returning to the Governor General's Decree dated July 27, 1932, which previously had six time zones. This made Papua from GMT +9 to GMT +9:30.[13]

---

[11] Hendaru Tri Hanggoro, "Kisah Zona Waktu di Indonesia," *HistoriA: Masa Lampau Selalu Aktual*, 2012, https://historia.id/sains/articles/kisah-zona-waktu-di-indonesia-DA1ND.

[12] Mochamad Harris, "Pembagian Waktu di Indonesia, WIB, WITA, WIT," *Gramedia.Com*, n.d., https://www.gramedia.com/literasi/pembagian-waktu-di-indonesia/?srsltid=AfmBOoqH1feTdzvz4e73RSMq7h-OVLpZvMwTq5b3vcBVQo95u1yJprUX.

[13] Guruh Muammar Khadafi, *Ibukota Negara Pindah ke Nusantara Indonesia Satu Zona Waktu* (Sumedang: Puslatbang PKASN, 2022).

The eighth change occurred in 1963. The President of Indonesia, through Presidential Decree No.243 Year 1963, divided the territory of Indonesia into 3 time zones, namely western, central, and eastern, which officially came into effect on January 1, 1964. Irian Jaya, which has returned to Indonesian territory, is included in the east zone along with the Maluku level 1 region because it is located at 135° east longitude. Central Indonesia includes tier 1 areas in Kalimantan, Sulawesi, and Nusa Tenggara, the longitude of which is 120°. Level 1 and unique regions in Sumatra, Java, Madura, and Bali are included in the western zone because their longitude lies at 105° east longitude.

Furthermore, the last time zone change occurred in 1987. For the first time, the economic and tourism sectors were considered. At that time, tourists who came to Bali began always to calculate the time. The two-hour time difference caused Japanese and Australian tourists to leave Bali early to avoid late nights back home. Subsequently, Bali's time zone line was changed to WITA by Presidential Decree Number 41 of 1987.[14] The Presidential Decree came into effect on January 1, 1988.

2. Presidential Decree Number 41 of 1987

Three considerations consider the Presidential Decree No. 41 of 1987. The first is that the division of time has an important role in supporting the smooth operation of government in the broadest sense of the word and in efforts to increase work efficiency in all fields. Second, the current division of time is now based on time and geographical realities, particularly in some areas of West Kalimantan, Central Kalimantan, and Bali, than the current time division of the province of Level I Bali. Third, the government deemed it necessary to reorganize the division of time in Indonesia as follows the division of time areas in Indonesia as stipulated in Presidential Decree Number 243 of 1963.[15]

Then, based on the considerations, the law decided to divide Indonesia into three time zones, including:

a. West Indonesia Time (GMT +7 with 105° East), covering All Provinces of Level 1 Sumatra; All Provinces of Level 1 Java and Madura; Province of Level 1 West Kalimantan; and Province of Level 1 Central Kalimantan.

[14] Keputusan Presiden (Keppres) Nomor 41 Tahun 1987 tentang Pembagian Wilayah Republik Indonesia Menjadi 3 (Tiga) Wilayah Waktu.

[15] Ibid.

b. Central Indonesian Time (GMT +8 with 120° east), including the Province of East Kalimantan, Province of South Kalimantan, Province of Bali, Province of West Nusa Tenggara, Province of East Nusa Tenggara, Province of East Timor; and All Provinces of Sulawesi.
c. Eastern Indonesia Time (GMT +9 with 135° East benchmark), including the Province of Maluku and Irian Jaya.

Based on the Presidential Decree, Indonesia's main principle behind the division of time zones is to avoid time zone boundaries dividing a province or island. The regulation is made as simple as possible so that it can be understood that the difference between solar time and benchmark time is manageable, especially in large areas.[16]

3. Banyuwangi Regency, East Java

Based on the time zone in Indonesia, Java was included in time zone +7, even though some minutes are different after the hour. Java and Madura are the first islands in Indonesia to establish an initial time zone, unlike the other islands in Indonesia. This is due to the colonization that took over Java and its surroundings. Moreover, east Java is still on one island with Central Java, where it was Indonesia's zero point. Therefore, since the beginning, East Java is on GMT+7.

Logically, the region that is sensitively impacted by the changing time zone is the island's edge, Banyuwangi. This is because the main principle of shifting time division is avoiding the boundaries dividing an island or province.

Banyuwangi is one of the regencies in East Java Province, located at the eastern tip of Java Island. Its territory is bordered by Situbondo Regency in the north, the Indian Ocean in the south, Jember and Bondowoso Regencies in the west, and the Bali Strait in the east. Banyuwangi Regency has 25 sub-districts and 217 villages.[17] Banyuwangi Regency is located at 7°43' N - 8°46' N and 113°53' E - 114°38' E with a coastline length of approximately 175.8 km. Its total area is 5,782.50 km^2, making it the largest regency in East Java Province.[18]

[16] Khadafi, *Ibukota Negara Pindah ke Nusantara Indonesia Satu Zona Waktu,* 2.
[17] Pemerintah Banyuwangi, "Geografi Daerah Banyuwangi," *Banyuwangikab.Go.Id*, n.d., https://banyuwangikab.go.id/profil-daerah/geografi.
[18] Banyuwangi, *Kabupaten Banyuwangi dalam Angka 2023,* 3.

In this research, one problematic loci from the author's point of view is Banyuwangi. Banyuwangi has a large population of Muslims who have needed on-time prayer to do their worship.

Islam entered Banyuwangi, marked by the existence of an Islamic propagator named Sheikh Maulana Ishak.[19], as recorded in several babad sources. Agus Sunyoto in Atlas Walisongo explains that two chapters tell the process of Islamization in Blambangan, namely Babad Tanah Jawi and Serat Walisana.[20] Sheikh Maulana Ishak, who at that time was meditating at the top of the mountain, received news from Patih Bajulsengara that there was a competition held by the King of Blambangan, Prabu Menak Sembuyu, to treat the disease suffered by his daughter, Dewi Sekardadu. The disease did not only affect Dewi Sekardadu but also other palace residents. Long story short, Sheikh Maulana Ishak treated Dewi Sekardadu by praying and asking Allah to heal her.[21]

After successfully curing Dewi Sekardadu, Sheikh Maulana Ishak was considered influential by the people of Blambangan. His magic spread to all corners of the Blambangan region. Thus, many people were interested in embracing Islam with their awareness. Since then, Sheikh Maulana Ishak has been preaching to spread Islam to the people of Blambangan. The first thing he did was build a mosque.[22] Over time, the number of followers of Sheikh Maulana Ishak increased. So, the adherents of Hinduism are increasingly pressed, their adherents are decreasing, and even the palace officials and relatives of the King's family are attracted to Islam.[23] However, the process of proselytizing could have gone smoother because the King of Menak Sembuyu refused Islam to enter his territory.

Meanwhile, the second Islamization process occurred during colonialism in the mid-18th century. Blambangan became the last Hindu kingdom before it was finally overthrown by the colonialists and turned into the Duchy of Banyuwangi in 1774. It was only then that Islamic proselytization began to enter and run smoothly.

---

[19] Sheikh Maulana Ishak is the son of Sykeh Ibrahim as Samarqandi or by another name Ibrahim Makdum Asmoro, from his marriage to a Cambodian woman. Meanwhile, Ibrahim as-Samarqandi was the son of Sheikh Jumadil Kubro.

[20] Agus Sunyoto, *Atlas Walisongo* (Depok: Pustaka IIMAN, 2012), 168.

[21] Ayung Notonegoro, *Islam Blambangan: Kisah, Tradisi, dan Literasi* (Sidoarjo: Delta Pijar Khatulistiwa, 2020), 12.

[22] Wahyu Setya Budi, "Dinamika Perkembangan Islam Pada Masyarakat Osing di Desa Kemiren Kabupaten Banyuwangi Pada Tahun 1965-2019" (IAIN Jember, 2020), 36.

[23] Umar Hasyim, *Sunan Giri* (Kudus: Menara Kudus, 1979), 25.

The interference of colonial rulers colored the process of cultural dialectics. The colonial rulers desperately needed the political power of Islam. The colonials, overwhelmed by the resistance of local political forces, needed the presence of the color of Islam with a political face of power to counter the resisting local rulers.[24]

The arrival of the colonials brought efforts to Islamize Blambangan. One of them was when Tumenggung Wiraguna, the son of Prince Danuningrat[25], was appointed Banyuwangi Regent on January 3, 1774. This was favorable to the Dutch. On the one hand, Tumenggung Wiraguna was a nobleman in Blambangan. On the other hand, he embraced Islam, making it possible that he would enter into a political alliance with the rebellious Balinese kingdom.[26]

Massively, the development of Islam in Banyuwangi occurred during the period of Regent Pringgokusumo (fifth Banyuwangi Regent, 1867-1881). He was not only known as a nobleman but also as a scholar. During the Pringgokusumo Regent, there was an Islamic preacher of Hadramaut descent, Sheikh Abdurrahim bin Abu Bakar Bauzir. Sheikh Abdurrahim initially preached in the Jembrana area of Bali. He came to Blambangan in 1770 and decided to stay in Banyuwangi. He lived in Arab Village, Lateng Village, and Banyuwangi. In that village, he was also buried.[27]

Islam, which was initially not too much, began to flourish and became the dominant religion in Banyuwangi. With this, the authors set several research loci in Banyuwangi, which are astronomically located close to Bali Island, namely Ketapang Village, Alas Purwo National Park, Kalibaru Manis Village, and Sarongan Village.

Table 1
Astronomical data of locus in Banyuwangi

Locus	**Ketapang Village**	**National Park Alas Purwo**	**Kalibaru Manis Village**	**Sarongan Village**
Latitude	08° 08’ 36.60” S	8° 38’ 33,40” S	08° 16’ 26.27” S	08° 32’ 08.00” S
Longitude	114° 23’ 57.72” E	114° 21’ 26,23” E	113° 57’ 31.90” E	113° 58’ 00.93” E
Sub-district	Kalipuro	Tegaldlimo and Purwoharjo	Kalibaru	Pesanggaran

[24] Budi, “Dinamika Perkembangan Islam Pada Masyarakat Osing di Desa Kemiren Kabupaten Banyuwangi Pada Tahun 1965-2019, 37-38.”
[25] Pangeran Adipati Danuningrat was the last Blambangan King to embrace Islam.
[26] Notonegoro, *Islam Blambangan: Kisah, Tradisi, dan Literasi,* 26.
[27] PCNU Banyuwangi, *Sejarah NU Banyuwangi* (Yogyakarta: LKiS, 2016), 24.

4. Jembrana Regency, Bali

Bali is located between the islands of Java and Lombok. At the beginning of Indonesian independence, Bali was included in the province of Sunda Kecil, including Lombok, Sumbawa, Sumba, Flores, and Timor. In 1958, Bali officially became its province, with Singaraja as the capital. Then, in 1960, it moved to Denpasar. Bali Province consists of about 85 islands, namely Bali Island as the largest island, Menjangan Island, Nusa Ceningan Island, Nusa Lembongan Island, Nusa Penida Island, Serangan Island, and other uninhabited islands.[28]

Geographically, Bali Province is located between 8°03'40" - 8°50'48" N and 114°25'53"- 115°42'40" E, divided into land areas and sea areas which become the boundaries of the province, namely: Bali Sea in the North, Indian Ocean in the South, Bali Strait in the West, Lombok Strait in the East. Bali has an area of 5,636.66 km^2 and has eight regencies, including Tabanan Regency, Jembrana Regency, Badung Regency, Buleleng Regency, Bangli Regency, Gianyar Regency, Klungkung Regency, Karangasem Regency and one municipality, Denpasar City.[29]

Bali initially used something other than GMT +8. In 1924, *Hoofden van Gewestelijk Bestuur in de Buitengewestan* created a new rule for the time division. When central Java was set to GMT +7:20, Bali had a time difference of +22 minutes from central Java time. Thus, Bali was included in the GMT +7:42. This shows that Bali was originally outside the GMT +8 time zone. Through all the shifting, the last change was in 1987; this was the first time the government counted on the economy and tourism. At that time, tourists coming to Bali began to calculate time. The two-hour time difference caused Japanese and Australian travelers to leave Bali quickly so as not to arrive early enough at night in their countries. Subsequently, the time zone line in Bali was changed to WITA by Presidential Decree No. 41/1987.[30]

This division aims to simplify the time administration throughout Indonesia, facilitate coordination between regions, and facilitate communication and

[28] Dinas Pekerjaan Umum Penataan Ruang Perumahan dan Kawasan Pemukiman Pemerintah Provinsi Bali, "Laporan Analisis Awal MASIKIAN," *Tarubali.Baliprov.Go.Id*, 2023, https://tarubali.baliprov.go.id/laporan-analisis-awal-masikian/.

[29] Amboro and Saptari, *Provinsi Bali dalam Angka 2023,* 35-36.

[30] Fachrezy Zulfikar, "Zona Waktu di Indonesia Pernah Berubah 9 Kali! Gimana Ceritanya?," *Goodnewsfromindonesia.Id*, 2018, https://www.goodnewsfromindonesia.id/2018/06/17/zona-waktu-di-indonesia-pernah-berubah-9-kali-gimana-ceritanya.

transportation. WITA, which includes Bali, is now the time reference for areas in central Indonesia.

Some other reasons why Bali was included in WITA are its geographical proximity to Nusa Tenggara and East Kalimantan, which have longitudes closer to the UTC+8 meridian, and adjusting to the division of time zones is efficient for national activities such as communication, trade, and transportation.

Islam in Bali is a minority religion embraced by approximately 432.25 people.[31] It is the largest Muslim community in Denpasar, with over 200 thousand people. There are several Muslim communities or Islamic villages in several areas of Bali, such as Kepaon Islamic village and Wanasari Islamic village in Denpasar city, Pegayaman Islamic village in Buleleng district, Candi Kuning Bedugul Islamic village in Tabanan district, Gelgel Islamic village in Klungkung district, Kecicang Islamic village in Karangasem district, and Loloan Islamic village and Gilimanuk Islamic village in Jembrana district.

Jembrana, the westernmost regency of Bali, also has a diverse population. The spread of the Muslim community there is not only limited to the village of Loloan (the center of Jembrana City) but also in the westernmost area of Jembrana, namely Gilimanuk, which is quite significant in number. One of the villages with the largest Muslim population is Loloan.

With this in mind, the author sets two research sites in Bali that are astronomically located close to the border of Bali and the Bali Strait, namely Gilimanuk and Negara. Both loci are close to Banyuwangi, East Java.

Table 2
Astronomical data of locus in Jembrana

Locus	Gilimanuk	Negara
Latitude	08° 10’ 19.10” S	08° 22’ 06.65” S
Longitude	114° 26’ 08.75” E	114° 37’ 23.20” E
Sub-district	Melaya	Negara

5. Ephemeris Data in Determining Prayer Times

In calculating prayer time, al Hasib will need data from Ephemeris referring to the motion of the Sun and not only using the geographical data of a place. The geographical data is Kaaba's coordinates (latitude and longitude) and the observer's

[31] BPS Provinsi Bali, “Statistic Data of Bali,” 2023, https://bali.bps.go.id/id.

place (latitude and longitude). The Ephemeris data referring to the Sun's motion is the Sun's declination and equation of time. Both of them always change every time.[32]

Sun's declination is the distance between the position of the Sun and the celestial equator measured along the circle of declination or the circle of time. The values of this declination are varied from -23.5° to +23.5°. The value of the Sun's decline changes from day to day and even from hour to hour during the year, but from year to year, it is slightly different. The Sun is on the celestial equator's zero or center in each equinox. In every solstice, the maximum value of the declination is -23.5° (winter solstice) and +23.5° (summer solstice). Those are the variations of the Sun's motion through the celestial equator.[33]

The equation of time is a correction to determine solar mean time from apparent solar time. Each region on Earth experiences differences in time averaging adjusted to the Sun's current position against the Earth. Therefore, to determine the time of the Sun's upper culmination, we need to choose the meridian pass by subtracting the upper meridian (noon) from the equation of time.[34]

6. The Distinctions of Ephemeris Data Retrieval based on astronomical locations between time zones

Time zones help organize time across regions as a uniform standard time for legal, social, and commercial purposes. Time zones are born from the division of the Earth into 24 parts using the zero meridian as a reference that varies according to location. GMT (Greenwich Mean Time) is the universal time and time zone benchmark.[35]

The ideal time zone is every 15° different by 1 hour. However, each country's considerations differ, so the world's time zone shifts following the country's borders

[32] Encep Abdul Rojak, Ilham Mujahid, and Muhammad Yunus, "The Accuracy of Online-Based Prayer Times Applications," *Ijtihad : Jurnal Wacana Hukum Islam dan Kemanusiaan* 21, no. 1 (June 30, 2021): 21–38, doi:10.18326/ijtihad.v21i1.21-38.

[33] Karen B. De Melo et al., "Accuracy Analysis of Sun Position Calculation Algorithms: Ineichen and SPA," in *2019 IEEE PES Conference on Innovative Smart Grid Technologies, ISGT Latin America 2019*, 2019, doi:10.1109/ISGT-LA.2019.8895282.

[34] Benno van Dalen, "Al-Khwārizmī's Astronomical Tables Revisited: Analysis of the Equation of Time," in *Islamic Astronomical Tables* (London: Routledge, 2023), IV_195-IV_252, doi:10.4324/9781003421016-4.

[35] Youla Afifah Azkarrula and Sartika, "An Analytical Evaluation of Fiqh and Science Perspective Concerning Hajj: Tarwiyah and Arafat," *Al Qalam* 39, no. 1 (2022): 40–54, doi:10.32678/alqalam.v39i1, 45.

or state boundaries.[36] The selection of time zones must be adequately considered because they impact various aspects of people's lives, including socio-political impacts, economic impacts related to energy savings and efficiency of working hours, and psychological and biological effects on society.

In this case, Jembrana Regency-Bali is astronomically located in the West Indonesia time zone (WIB). However, the region currently uses the Central Indonesian time zone (WITA). This is based on Presidential Decree No. 41 of 1987 concerning the division of the territory of the Republic of Indonesia into 3 Time Regions. Bali Province, especially Jembrana Regency, is included in the Central Indonesia time zone (WITA). The Central Indonesian time zone (WITA) is along the 120° East line or GMT +8 hours. The time difference between West Indonesia time (WIB) and East Indonesia time (WITA) is 1 hour.

This resulted in a difference in the data retrieval process in the ephemeris table to calculate the beginning of the prayer time in the Jembrana-Bali Regency area, which should have taken data from +7 GMT to +8 GMT. The ephemeris data affected includes Sun Declination, EoT (Equation of Time), Meridian Pass, and Semi Diameter of the Sun. The difference can be seen in Figure 1:

Jam	Ecliptic Longitude *)	Ecliptic Latitude *)	Apparent Right Ascension	Apparent Declination	True Geocentric Distance	Semi Diameter	True Obliquity	Equation Of Time
0	141° 56' 50"	0.86"	144° 18' 27"	14° 11' 42"	1.0130003	15'47.31"	23° 26' 19"	-4 m 39 s
1	141° 59' 14"	0.86"	144° 20' 47"	14° 10' 55"	1.0129929	15'47.32"	23° 26' 19"	-4 m 38 s
2	142° 01' 38"	0.86"	144° 23' 08"	14° 10' 09"	1.0129855	15'47.33"	23° 26' 19"	-4 m 38 s
3	142° 04' 02"	0.86"	144° 25' 29"	14° 09' 22"	1.0129781	15'47.34"	23° 26' 19"	-4 m 37 s
4	142° 06' 26"	0.86"	144° 27' 49"	14° 08' 35"	1.0129707	15'47.34"	23° 26' 19"	-4 m 37 s
5	142° 08' 50"	0.86"	144° 30' 10"	14° 07' 49"	1.0129632	15'47.35"	23° 26' 19"	-4 m 36 s
6	142° 11' 14"	0.86"	144° 32' 31"	14° 07' 02"	1.0129558	15'47.36"	23° 26' 19"	-4 m 36 s
7	142° 13' 38"	0.86"	144° 34' 51"	14° 06' 15"	1.0129484	15'47.36"	23° 26' 19"	-4 m 35 s
8	142° 16' 03"	0.86"	144° 37' 12"	14° 05' 29"	1.0129409	15'47.37"	23° 26' 19"	-4 m 35 s
9	142° 18' 27"	0.86"	144° 39' 32"	14° 04' 42"	1.0129334	15'47.38"	23° 26' 19"	-4 m 34 s
10	142° 20' 51"	0.86"	144° 41' 53"	14° 03' 55"	1.0129260	15'47.38"	23° 26' 19"	-4 m 34 s
11	142° 23' 15"	0.85"	144° 44' 13"	14° 03' 08"	1.0129185	15'47.39"	23° 26' 19"	-4 m 33 s
12	142° 25' 39"	0.85"	144° 46' 34"	14° 02' 22"	1.0129110	15'47.40"	23° 26' 19"	-4 m 33 s
13	142° 28' 03"	0.85"	144° 48' 54"	14° 01' 35"	1.0129035	15'47.41"	23° 26' 19"	-4 m 32 s
14	142° 30' 27"	0.85"	144° 51' 15"	14° 00' 48"	1.0128960	15'47.41"	23° 26' 19"	-4 m 32 s
15	142° 32' 52"	0.85"	144° 53' 35"	14° 00' 01"	1.0128885	15'47.42"	23° 26' 19"	-4 m 31 s
16	142° 35' 16"	0.85"	144° 55' 56"	13° 59' 14"	1.0128809	15'47.43"	23° 26' 19"	-4 m 31 s
17	142° 37' 40"	0.85"	144° 58' 16"	13° 58' 27"	1.0128734	15'47.43"	23° 26' 19"	-4 m 30 s
18	142° 40' 04"	0.85"	145° 00' 37"	13° 57' 40"	1.0128659	15'47.44"	23° 26' 19"	-4 m 30 s
19	142° 42' 28"	0.84"	145° 02' 57"	13° 56' 53"	1.0128583	15'47.45"	23° 26' 19"	-4 m 29 s
20	142° 44' 52"	0.84"	145° 05' 18"	13° 56' 06"	1.0128508	15'47.45"	23° 26' 19"	-4 m 29 s
21	142° 47' 17"	0.84"	145° 07' 38"	13° 55' 19"	1.0128432	15'47.46"	23° 26' 19"	-4 m 28 s
22	142° 49' 41"	0.84"	145° 09' 58"	13° 54' 32"	1.0128356	15'47.47"	23° 26' 19"	-4 m 28 s
23	142° 52' 05"	0.84"	145° 12' 19"	13° 53' 45"	1.0128280	15'47.48"	23° 26' 19"	-4 m 27 s
24	142° 54' 29"	0.84"	145° 14' 39"	13° 52' 58"	1.0128204	15'47.48"	23° 26' 19"	-4 m 27 s

*) for mean equinox of date

Figure I
Data of Sun Ephemeris
Source: Indonesian Ministry of Religious Affairs's Ephemeris Book[37]

[36] Thomas Djamaluddin, *Kajian Astronomi Perubahan Zona Waktu Indonesia* (Bandung: LAPAN, 2012), 2.

[37] Kementrian Agama, *Ephemeris Hisab Rukyat 2023* (Jakarta: Kementrian Agama RI, 2022).

Based on Figure 1, each hour has different data for each column, and the other data from each column are distinctive. If the difference in ecliptic longitude is roughly three minutes degrees each hour, then it will not be in the different columns because they have their formulae.

7. The Comparison of Differences in the Use of Time Zone in Ephemeris Data Retrieval in Prayer Time Calculation

With the problems in Ephemeris data retrieval for the case of Western and Central Indonesian time zones, especially Bali, the author compares the results of hisab early prayer time in Banyuwangi and Jembrana areas, using two time zones, namely WIB and WITA. Each locus is calculated using both time zones to see the difference. The calculation of the beginning of prayer time uses the date August 15, 2023, the data of which can be seen in Figure 1. The results of the calculation of the beginning of prayer time for the six loci are as follows:

Table 3
Result of Hisab for the Beginning of Prayer Time with Ephemeris GMT +7 and GMT +8 data

Prayer	Results of GMT +7 Ephemeris data	Results of GMT +8 Ephemeris data	Difference
Ketapang Village (GMT +7)			
Zuhr	11: 29 : 0	12: 29: 1	1 hour 1 second
Asr	14: 50: 12	15: 50: 13	1 hour 1 second
Maghrib	17: 24: 11	18: 24: 11	1 hour 0 second
Isha	18: 32: 35	19: 32: 36	1 hour 1 second
Fajr	4: 17: 9	5: 17: 10	1 hour 1 second
Imsak	4	: 7: 9 5: 7: 10	1 hour 1 second
Rise	5: 29: 49	6: 29: 51	1 hour 2 second
Duha	5: 56: 6	6: 56: 7	1 hour 1 second
Alas Purwo National Park (GMT +7)			
Zuhr	11: 28: 12	12: 28: 13	1 hour 1 second
Asr	14: 49: 21	15: 49: 22	1 hour 1 second
Maghrib	17: 22: 47	18: 22: 47	1 hour 0 second
Isha	18: 31: 16	19: 31: 17	1 hour 1 second
Fajr	4: 16: 51	5: 16: 52	1 hour 1 second
Imsak	4	: 6: 51 5: 6: 52	1 hour 1 second
Rise	5: 29: 37	6: 29: 39	1 hour 2 second
Duha	5: 55: 56	6: 55: 57	1 hour 1 second

Prayer	Results of GMT +7 Ephemeris data	Results of GMT +8 Ephemeris data	Difference
Kalibaru Manis Village (GMT +7)			
Zuhr	11: 30: 44	12: 30: 45	1 hour 1 second
Asr	14: 51: 55	15: 51: 57	1 hour 2 second
Maghrib	17: 25: 46	18: 25: 47	1 hour 1 second
Isha	18: 34: 12	19: 34: 13	1 hour 1 second
Fajr	4: 18: 60	5: 19: 1	1 hour 1 second
Imsak	4	: 8: 60 5: 9: 1	1 hour 1 second
Rise	5: 31: 42	6: 31: 43	1 hour 1 second
Duha	5: 57: 58	6: 57: 60	1 hour 2 second
Sarongan Village (GMT +7)			
Zuhr	11: 30: 8	12: 30: 9	1 hour 1 second
Asr	14: 51: 18	15: 51: 19	1 hour 1 second
Maghrib	17: 24: 51	18: 24: 51	1 hour 0 second
Isha	18: 33: 19	19: 33: 20	1 hour 1 second
Fajr	4: 18: 40	5: 18: 41	1 hour 1 second
Imsak	4	: 8: 40 5: 8: 41	1 hour 1 second
Rise	5: 31: 25	6: 31: 27	1 hour 2 second
Duha	5: 57: 43	6: 57: 44	1 hour 1 second
Gilimanuk (GMT +8)			
Zuhr	11: 28: 52	12: 28: 53	1 hour 1 second
Asr	14: 50: 4	15: 50: 5	1 hour 1 second
Maghrib	17: 24: 4	18: 24: 4	1 hour 0 second
Isha	18: 32: 28	19: 32: 29	1 hour 1 second
Fajr	4: 16: 60	5: 17: 1	1 hour 1 second
Imsak	4	: 6: 60 5: 7: 1	1 hour 1 second
Rise	5: 29: 40	6: 29: 42	1 hour 2 second
Duha	5: 55: 57	6: 55: 58	1 hour 1 second
Negara (GMT +8)			
Zuhr	11: 27: 60	12: 28: 1	1 hour 1 second
Asr	14: 49: 11	15: 49: 12	1 hour 1 second
Maghrib	17: 22: 57	18: 22: 58	1 hour 1 second
Isha	18: 31: 24	19: 31: 24	1 hour 0 second
Fajr	4: 16: 20	5: 16: 21	1 hour 1 second
Imsak	4	: 6: 20 5: 6: 21	1 hour 1 second
Rise	5: 29 : 3	6: 29: 4	1 hour 1 second
Duha	5: 55: 20	6: 55: 21	1 hour 1 second

Table 3 shows the results of prayer time calculation for the Jembrana and Banyuwangi regions, each calculated using GMT+7 and +8 time zones. Each location uses two kinds of data retrieval from GMT +7 and +8 ephemeris data. Table 3 shows a difference in each result besides adding the time zone. The average difference in using different ephemeris data shows a difference in the range of seconds, from 1 to 2 seconds. The difference in hours is obtained when entering into the regional time correction (local correction time) formula, where the difference between the region's longitude and the place's longitude is divided by 15. If using GMT +7, enter 105 ° in the region's longitude. However, if using GMT +8, input 120° into the longitude of the area. The description of the difference in longitude input only affects the time zone, namely:

Table 3

Difference in Time Zone

GMT +7	**GMT +8**
$= 12h + \frac{\lambda d - \lambda t}{15}$ $= 12h + \frac{(105° - 110°)}{15}$ $= 12h + (-0°\ 20'0'')$ $= 11{:}40$	$= 12h + \frac{\lambda d - \lambda t}{15}$ $= 12h + \frac{(120° - 110°)}{15}$ $= 12h + (0°\ 40'0'')$ $= 12{:}40$

In Table 4, the difference in regional longitude or time zone input in regional time correction does not give an output that exceeds the difference in the time zone used.

If Hasib incorrectly inputs solar ephemeris data into the formula, then this will not cause a significant difference in output results. This analysis is obtained from an example, namely if it should use GMT +8 data for the Bali region (taking data at 4 o'clock because 12 minus eight is 4), but what is used is GMT +7 data (taking data at 5 o'clock because 12 minus seven is 5), it will only affect the range of seconds as shown in table 3. This range of seconds will not significantly affect the calculation of the beginning of prayer time. The subsequent rounding of seconds to minutes will make up for this difference. In addition, ihtiyat was added from the results of the previous rounding. This is not too influential as long as the ephemeris data taken is still on the same date.

The problem is hanging on to time zone determination. Meanwhile, the rest of the prayer time difference in minutes and seconds will have a negligible influence if

it is still on the same date and uses the correct time zone to calculate regional time correction. From the Presidential Decree Number 41 of 1987 and the calculations in Tables 3 and 4, it could be implied that if some ships or humans are in the time division line at the sea between Jembrana and Banyuwangi, then the time will shift. The shifting time will affect the time zone simultaneously with the time prayer result but will not have more effect on prayer time minutes.

8. The Effect of the Ephemeris Data Retrieval on Religious Observance

Islam must worship based on time, which is tied to the position of celestial bodies. The main focus of this article is to observe the effect of ephemeris data retrieval on prayer time. The other thing besides prayer time is fasting. In this case, the fasting is linked to the astronomical twilight and dawn. Those times are the markers of the time to stop eating for fasting and take an evening break for fasting (iftar). This is why prayer times are the most crucial time to calculate.

Falak experts have attempted to interpret the prayer timers in the Hadith by converting them into observations that we can then find in the form of formulas today. This makes it easier for users to determine the beginning of prayer time. However, the ease of this technology makes Muslims less able to read the verses of *kawniyah* in nature. This makes Muslims more dependent on things that are more practical and digitalized. Because of this habit, Muslims often encounter difficulties determining the beginning of prayer time. This is more related to the collection of ephemeris data and time zones.

If we apply the wrong data, there will be errors in the results of prayer time calculations. For instance, if the ship at sea has entered the GMT+8 time zone but the passengers still consider it to be in GMT+7, this can affect certain critical times, namely Fajr and Imsak, which are related to sahur and maghrib, which are associated with breaking the fast. This is why we need some solutions to overcome this problem. The passengers could update their current locations in Android apps to update the time prayers. Many Muslims today rely on prayer time apps that automatically adjust based on location. However, problems arise when these apps do not accurately account for time differences in specific regions or when users are in areas that GPS needs to cover better.

Prayer time apps are often adjusted based on local time zones. Problems can occur if users do not update their location in the app when moving from Banyuwangi to Bali or vice versa. The app may still show the schedule based on the previous location, which could cause someone to pray early or late, even when fasting. In this case, the signal at the sea does not always work. Then, the ship crews, especially for the Jembrana-Banyuwangi expedition, could announce the prayer times, especially Fajr and Maghrib.

D. Conclusion

Jembrana Regency, Bali, and Banyuwangi Regency, East Java, are astronomically close in terms of latitude and longitude. Astronomically, Bali does belong to the Western Indonesian time zone (WIB). However, the government's consideration of the economic sector makes Jembrana Regency, especially Bali, enter the Central Indonesian time zone. This consideration is contained in Presidential Decree No. 41 of 1987, effective January 1, 1988. When examined against solar ephemeris data collection, this time zone change does not significantly affect the calculation of the beginning of prayer time. Roughly speaking, the prayer time at the end of Banyuwangi and the end of Jembrana, namely Gilimanuk, only has a difference of about two minutes. So if in Jembrana it is time to pray and call to prayer, then about two minutes more, Banyuwangi will enter the time of worship and call to prayer.

This an-hour difference is only in the time zone, which means not waiting an hour later between islands. Thus, if Jembrana is at noon, then Banyuwangi is at 11:00. In addition, if a Hasib mistakenly takes ephemeris data at different GMT hours even though it is still in one date time, then this does not have a significant impact. This is proven by the difference in data collection with a 1-hour time zone only affecting the range of seconds. The results of these seconds will not interfere with the output of determining the beginning of prayer time because the results will be rounded to minutes and do the *iḥtiyāṭ* following the provisions of the type of fard prayer being calculated.

E. Bibliography

Amboro, Nasehat Tono, and Surya Hanggea Saptari. *Provinsi Bali dalam Angka 2023*. Bali: BPS Provinsi Bali, 2023.

Azkarrula, Youla Afifah, and Sartika. “An Analytical Evaluation of Fiqh and Science

Perspective Concerning Hajj: Tarwiyah and Arafat." *Al Qalam* 39, no. 1 (2022): 40–54. doi:10.32678/alqalam.v39i1.

BPS Banyuwangi. *Kabupaten Banyuwangi dalam Angka 2023*. Banyuwangi: BPS Kabupaten Banyuwangi, 2023.

BPS Provinsi Bali. "Statistic Data of Bali," 2023. https://bali.bps.go.id/id.

Budi, Wahyu Setya. "Dinamika Perkembangan Islam Pada Masyarakat Osing di Desa Kemiren Kabupaten Banyuwangi Pada Tahun 1965-2019." IAIN Jember, 2020. http://digilib.uinkhas.ac.id/12931/1/Wahyu Setya Budi_U20164012.pdf.

Dalen, Benno van. "Al-Khwārizmī's Astronomical Tables Revisited: Analysis of the Equation of Time." In *Islamic Astronomical Tables*, IV_195-IV_252. London: Routledge, 2023. doi:10.4324/9781003421016-4.

Dinas Pekerjaan Umum Penataan Ruang Perumahan dan Kawasan Pemukiman Pemerintah Provinsi Bali. "Laporan Analisis Awal MASIKIAN." *Tarubali.Baliprov.Go.Id*, 2023. https://tarubali.baliprov.go.id/laporan-analisis-awal-masikian/.

Djamaluddin, Thomas. *Kajian Astronomi Perubahan Zona Waktu Indonesia*. Bandung: LAPAN, 2012.

Hanggoro, Hendaru Tri. "Kisah Zona Waktu di Indonesia." *HistoriA: Masa Lampau Selalu Aktual*, 2012. https://historia.id/sains/articles/kisah-zona-waktu-di-indonesia-DA1ND.

Harris, Mochamad. "Pembagian Waktu di Indonesia, WIB, WITA, WIT." *Gramedia.Com*, n.d. https://www.gramedia.com/literasi/pembagian-waktu-di-indonesia/?srsltid=AfmBOoqH1feTdzvz4e73RSMq7h-OVLpZvMwTq5b3vcBVQo95u1yJprUX.

Hasyim, Umar. *Sunan Giri*. Kudus: Menara Kudus, 1979.

Junaidi, Ahmad. "Penyatuan Zona Waktu Indonesia dan Implikasinya Pada Waktu Ibadah." *Justicia Islamica* 9, no. 2 (2012). doi:10.21154/justicia.v9i2.350.

Kementrian Agama. *Ephemeris Hisab Rukyat 2023*. Jakarta: Kementrian Agama RI, 2022.

Khadafi, Guruh Muammar. *Ibukota Negara Pindah ke Nusantara Indonesia Satu Zona Waktu*. Sumedang: Puslatbang PKASN, 2022.

Ma'u, Dahlia Haliah. "Jadwal Salat Sepanjang Masa di Indonesia (Studi Akurasi dan Batas Perbedaan Lintang dalam Konversi Jadwal Salat)." IAIN Semarang, 2013.

Melo, Karen B. De, Michelle Kitayama, Lucas R. Tavares, Hiram Andreazza De Freitas, and Marcelo Gradella Villalva. "Accuracy Analysis of Sun Position Calculation Algorithms: Ineichen and SPA." In *2019 IEEE PES Conference on Innovative Smart Grid Technologies, ISGT Latin America 2019*, 2019. doi:10.1109/ISGT-LA.2019.8895282.

Noor, Rahel Yulian, Saifullah, and Witri Dwi Julianti. "Perbedaan Waktu Ibadah Sholat Umat Islam di Berbagai Daerah." *Religion: Jurnal Agama, Sosial, dan Budaya* 2, no. 5 (2023): 173–82. doi:10.55606/religion.v1i5.271.

Notonegoro, Ayung. *Islam Blambangan: Kisah, Tradisi, dan Literasi*. Sidoarjo: Delta Pijar Khatulistiwa, 2020.

PCNU Banyuwangi. *Sejarah NU Banyuwangi*. Yogyakarta: LKiS, 2016.

Pemerintah Banyuwangi. "Geografi Daerah Banyuwangi." *Banyuwangikab.go.id*, n.d. https://banyuwangikab.go.id/profil-daerah/geografi.

Putri, Hasna Tuddar. "Relevance of Hijri Clock as a System of Determining the Time of Worship." *Tharwah Journal of Islamic Civilization and Thought* 1, no. 2 (2021). doi:10.47766/tharwah.v1i2.12.

Qomariyah, Nur. "Penentuan Awal Waktu Salat (Awal Waktu Salat Asar, Magrib, dan Isya Berdasarkan Hadis Nabi)." *Al-Afaq: Jurnal Ilmu Falak dan Astronomi*, 2021. doi:10.20414/afaq.v2i2.2918.

Rahmi, Nailur. "Penyatuan Zona Waktu dan Pengaruhnya Terhadap Penetapan Awal Waktu Shalat." *Juris* 13, no. 1 (2014): 75–83. doi:10.31958/juris.v13i1.1130.

Rojak, Encep Abdul, Ilham Mujahid, and Muhammad Yunus. "The Accuracy of Online-Based Prayer Times Applications." *Ijtihad : Jurnal Wacana Hukum Islam Dan Kemanusiaan* 21, no. 1 (June 30, 2021): 21–38. doi:10.18326/ijtihad.v21i1.21-38.

Suleman, Frangky. "Penentuan Awal Waktu Shalat." *Jurnal Ilmiah Al-Syir'ah* 9, no. 2 (2016). doi:10.30984/as.v9i2.31.

Sunyoto, Agus. *Atlas Walisongo*. Depok: Pustaka IIMAN, 2012.

Zulfikar, Fachrezy. "Zona Waktu di Indonesia Pernah Berubah 9 Kali! Gimana Ceritanya?" *Goodnewsfromindonesia.Id*, 2018. https://www.goodnewsfromindonesia.id/2018/06/17/zona-waktu-di-indonesia-pernah-berubah-9-kali-gimana-ceritanya.