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# QGIS-Based Visualization of Prayer Times According to Geographical Position in Makassar

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**ABSTRACT**

Determining prayer times is a fundamental aspect of Islamic worship, as each obligatory prayer is prescribed within a specific time interval associated with the apparent position of the Sun. In astronomical calculation, prayer times are determined using solar positional data together with the geographical coordinates of a given location. This study aims to analyze and visualize spatial variations in prayer times across Makassar City using Quantum Geographic Information System (QGIS). The research employed a quantitative descriptive approach by integrating astronomical calculation with geospatial analysis. Prayer-time data were obtained from official sources, particularly the Ministry of Religious Affairs of the Republic of Indonesia, and were compared with values calculated using contemporary *hisab* formulas. Geographic coordinates of selected observation points were collected through digital mapping platforms, while administrative and spatial datasets were obtained from official geospatial data providers. The data were then processed and visualized in QGIS to identify spatial patterns in prayer-time differences across Makassar. The results show that geographical position, particularly longitude, produces measurable variations in prayer times even within the boundaries of the same city. These differences range from several seconds to several minutes depending on the relative location of each observation point. Thematic maps generated through QGIS clearly illustrate the spatial distribution of these variations and provide a more intuitive representation than conventional tabular prayer schedules. The findings demonstrate that integrating astronomical calculation with Geographic Information System (GIS) technology offers an effective approach for analyzing and communicating spatial variations in prayer times. This study contributes to the development of digital Islamic astronomy by introducing a geospatial framework for prayer-time analysis that can support more location-sensitive calculation and visualization practices.

**ABSTRAK**

Penentuan waktu salat merupakan bagian penting dalam pelaksanaan ibadah umat Islam karena setiap salat fardu memiliki rentang waktu yang ditetapkan berdasarkan posisi semu Matahari. Dalam ilmu falak, waktu salat dapat dihitung melalui metode hisab dengan memanfaatkan data posisi Matahari serta koordinat geografis suatu lokasi. Penelitian ini bertujuan menganalisis dan memvisualisasikan variasi waktu salat di Kota Makassar berdasarkan posisi geografis dengan menggunakan Quantum Geographic Information System (QGIS). Penelitian ini menggunakan pendekatan kuantitatif deskriptif dengan mengintegrasikan perhitungan astronomis dan analisis spasial. Data waktu salat diperoleh dari sumber resmi, terutama Kementerian Agama Republik Indonesia, kemudian dibandingkan dengan hasil perhitungan manual menggunakan rumus hisab kontemporer. Data koordinat geografis titik pengamatan diperoleh melalui Google Maps, sedangkan data spasial administratif diperoleh dari sumber geospasial resmi, termasuk tanahair.indonesia.go.id. Seluruh data selanjutnya diolah dan divisualisasikan dalam QGIS untuk mengidentifikasi pola variasi waktu salat di wilayah Kota Makassar. Hasil penelitian menunjukkan bahwa posisi geografis, terutama perbedaan bujur, berpengaruh terhadap variasi waktu salat meskipun masih berada dalam satu wilayah kota yang sama. Perbedaan tersebut berkisar dari beberapa detik hingga beberapa menit, bergantung pada posisi relatif masing-masing titik pengamatan. Visualisasi dalam bentuk peta tematik QGIS mampu

menunjukkan distribusi spasial perbedaan waktu salat secara lebih jelas dibandingkan penyajian dalam bentuk tabel konvensional. Penelitian ini menunjukkan bahwa integrasi perhitungan astronomis dengan teknologi Sistem Informasi Geografis dapat menjadi pendekatan yang efektif untuk menganalisis dan mengomunikasikan variasi spasial waktu salat. Temuan ini berkontribusi pada pengembangan falak digital modern melalui pemanfaatan analisis geospasial yang lebih sensitif terhadap perbedaan lokasi.

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## INTRODUCTION

Prayer is one of the fundamental acts of worship in Islam, and its performance is bound to specific times. The determination of these times is closely related to observable solar phenomena, such as sunrise, sunset, solar culmination, and twilight. In Islamic astronomy, these phenomena are translated into astronomical parameters that allow prayer times to be calculated mathematically through *hisab* (Hafidhin, 2021). Thus, the determination of Fajr, Dhuhr, Asr, Maghrib, and Isha is not only based on normative religious texts but also on measurable celestial events and the geographical position of the observer.

The relationship between prayer times and geographical position is particularly important because solar altitude and apparent solar movement are experienced differently at different locations. Latitude and longitude influence the apparent position of the Sun and therefore affect the beginning and end of prayer times. Dhuhr begins when the Sun passes the local meridian and starts to move westward, while the beginning of Asr is determined through the length of an object's shadow in relation to its height. Likewise, Maghrib, Isha, and Fajr are associated with sunset and twilight phenomena (Syifa, 2020). These astronomical indicators demonstrate that prayer times are location-dependent and cannot be fully understood without considering the geographical coordinates of a particular place.

To simplify civil timekeeping, modern societies use standardized time zones based on selected meridians. This system is practical for administrative and social purposes, but it does not eliminate local astronomical differences. Within a single administrative region, locations situated at different longitudes may experience slight variations in local solar time. Consequently, prayer times calculated for one reference point may differ by several seconds or minutes from those at another location, even when both locations are within the same city (Hafidhin, 2021).

This issue is relevant in Makassar, where prayer schedules are generally presented uniformly for the entire urban area. Such standardization is understandable from a practical perspective because it provides simplicity and consistency for public use. However, it may obscure small spatial variations that arise from differences in geographical coordinates among sub-districts. These variations may be insignificant for general daily practice, but they are scientifically important in the context of Islamic astronomy because they reflect the direct relationship between local geography and solar-based time determination.

Geographical position is not merely an administrative description of a place, but an astronomical variable that influences the apparent position of celestial objects. Differences in latitude and longitude affect local observations of the Sun and therefore influence the calculation of prayer times. The importance of geographical coordinates in Islamic astronomical calculation has also been demonstrated in studies concerning *rashdul qiblah* and other location-based astronomical phenomena (Jamil, 2020).

The increasing use of digital technologies has transformed the way prayer-time information is produced and disseminated. Prayer times are now commonly accessed through mobile applications, websites, digital clocks, and printed schedules. Nevertheless, most of these platforms present prayer times in static numerical formats. Users are typically provided with a list of times without a spatial representation of how those times vary from one location to another. As a result, the geographical dimension of prayer-time calculation remains largely invisible to the public.

From the perspective of Islamic astronomy and geospatial science, this limitation creates an opportunity for methodological innovation. Geographic Information Systems (GIS) provide tools for integrating astronomical calculations with location-based data. In particular, QGIS enables the processing, analysis, and visualization of spatial information in the form of thematic maps. Through this platform, variations in prayer times can be mapped geographically, allowing users to observe how differences in latitude and longitude correspond to differences in calculated prayer times.

Previous studies have discussed the relationship between astronomy and religious practice from several perspectives. Syarif (2020), for example, emphasizes the integration of Islamic astronomy with modern science, particularly in relation to qibla direction, prayer times, the beginning of lunar months, and eclipses. His work demonstrates that *falak* is not only part of the classical Islamic scientific tradition but also a field that can be developed through contemporary scientific methods.

Other studies have also shown the potential of geospatial technology in Islamic astronomical research. The use of QGIS for mapping qibla direction, for instance, demonstrates that spatial technology can be used to visualize astronomical information in a more analytical and accessible form. Such studies indicate that GIS is not limited to geographical mapping, but can also function as an analytical instrument in the development of digital *falak* studies.

However, existing research has focused more heavily on either the astronomical calculation of prayer times or the use of GIS for qibla mapping. Relatively little attention has been paid to the spatial visualization of prayer-time variation within a single urban area. This leaves a gap in the literature, particularly regarding how prayer-time differences can be represented geographically at the sub-district level and how QGIS can be used as an analytical tool rather than merely as a mapping platform.

This study addresses that gap by integrating contemporary prayer-time calculations with geospatial analysis in Makassar. It focuses on the spatial distribution of prayer-time variations and examines the extent to which geographical coordinates influence differences in prayer times within the city. The study also evaluates the use of QGIS as a visualization tool for presenting these differences in a more informative and spatially explicit form.

Accordingly, this research has three main objectives. First, it examines the mechanism for determining prayer times based on geographical coordinates in Makassar. Second, it analyzes the extent to which variations in latitude and longitude contribute to differences in prayer times across sub-districts. Third, it applies QGIS to produce thematic visualizations that present these differences clearly and systematically. By combining astronomical calculation with geospatial analysis, this study contributes to the development of digital Islamic astronomy and offers a more spatially sensitive approach to understanding prayer-time determination.

## METHOD

This study employs a quantitative research design. Quantitative research is a systematic and objective approach to data collection and analysis that relies on numerical data to obtain valid and reliable information about a particular phenomenon or research problem (Waruwu et al., 2025). In this study, a descriptive quantitative approach is used with particular emphasis on spatial visualization. The main objective is to describe and analyze variations in prayer times based on differences in geographical position within Makassar City.

The research is non-experimental because it does not involve direct treatment or manipulation of variables. Instead, it analyzes numerical and spatial data derived from geographical coordinates, prayer-time calculations, and official prayer schedules. The results are presented in the form of Geographic Information System (GIS)-based thematic maps using QGIS software. This approach enables the relationship between geographical location and prayer-time variation to be examined spatially and visually.

The study area covers the administrative territory of Makassar City, South Sulawesi Province. The population consists of all sub-districts in Makassar, since each area has different geographical coordinates that theoretically may influence prayer-time calculations. However, the study does not use all sub-districts as observation units. Instead, selected locations are used as representative samples for spatial comparison.

The sample was determined through purposive sampling. Observation points were selected based on their ability to represent geographical variation across different parts of Makassar City. Three mosques were chosen as observation points: Amirul Mukminin Mosque in Ujung Pandang District, Raya Bukit Baruga Mosque in Manggala District, and Hj. Fatimah Mosque in Biringkanaya District. These locations were selected because they represent different geographical positions within the city and therefore provide an adequate basis for identifying and visualizing variations in prayer times.

Data collection was conducted through several stages. First, geographical coordinate data for each observation point were obtained using Google Maps. These coordinates were used to determine the latitude and longitude of each location. Second, official prayer-time schedules were collected from the Ministry of Religious Affairs of the Republic of Indonesia. These data were then compared with prayer times calculated manually using contemporary *hisab* formulas.

Third, spatial data were obtained from the official Ina-Geoportal database through tanahair.indonesia.go.id. The spatial datasets included administrative boundary data and other relevant geospatial information required for mapping. These data were processed in QGIS to produce thematic maps showing the spatial

distribution of prayer-time differences across the selected locations. Relevant academic references in Islamic astronomy, prayer-time calculation, GIS, and QGIS were also used to support the interpretation of the findings.

The data analysis was carried out descriptively and comparatively. Prayer-time values from the selected observation points were compared to identify differences associated with geographical coordinates. Particular attention was given to variations in longitude and latitude, as both variables influence the apparent solar position and local solar time. The differences were then visualized using QGIS in order to show the spatial pattern of prayer-time variation within Makassar City.

The analytical process involved three stages. First, the numerical differences in prayer times between observation points were identified. Second, the differences were mapped spatially using thematic visualization in QGIS. Third, the resulting spatial patterns were interpreted by relating them to astronomical and geospatial concepts. This procedure was used to evaluate the effectiveness of QGIS in presenting prayer-time variation in a form that is both scientifically informative and visually accessible.

Through this methodological framework, the study does not merely compare prayer-time values numerically, but also demonstrates how geographical variation can be translated into spatial patterns. The integration of contemporary *hisab* calculation and QGIS-based visualization therefore provides a methodological contribution to the development of digital Islamic astronomy.

## RESULTS AND DISCUSSION

### Method for Determining Prayer Times in the City of Makassar Based on Geographical Position Using Spatial Data

The sun appears to move, but in reality, it is the Earth that moves around the sun. Prayer times are influenced by the length of day and nite at each latitude or region.[1] Prayer times are affected by the movement of the sun and natural phenomena. That is why the existence of astronomy is very important to be used in determining prayer times to make it easier to determine prayer times (Fahamsyah, 2023). Astronomers use calculations (hisab) to determine the start times of prayers, including classical and contemporary calculations. Contemporary calculations utilize modern astronomical data (ephemeris) and more accurate trigonometric calculations. Thus, contemporary calculations allow for more precise results, especially when combined with spatial data such as latitude and longitude from the research location. The data used in contemporary calculations include latitude, longitude, regional longitude, altitude, meridian path, ihtiyath, as well as the date, month, and year (Fahamsyah, 2023).

How to Calculate the Beginning of Prayer Time. The required data is as follows:
Longitude

Longitude, which is the geographic position of a location measured from the Greenwich meridian and can be obtained thru applications like Google Maps or Geographic Information System (GIS) devices (Kemenag, 2010).

Regional Longitude

Regional longitude, which is the standard meridian used as a reference for dividing time zones in Indonesia, namely 105° E for WIB, 120° E for WITA, and 135° E

for WIT; for example, the city of Makassar, which is in the WITA zone, uses the regional longitude of 120° E (Abi, 2025).

Place Latitude

In geography, latitude (ϕ) is an imaginary line used to determine a location on Earth relative to the equator (north or south). Latitude is usually denoted by the Greek letter φ. Latitude is a measure of angle from 0° at the equator to +90° at the North Pole and -90° at the South Pole (Abi, 2025).

Equation of Time

Equation of Time, or in Indonesian known as Perata Waktu, is the difference between the time of the true solar noon and the time of the mean solar noon.[1] The value of EoT varies daily between ±16 minutes and can be obtained from the EphemerisMeeus application.

**The Influence of Geographic Position in Makassar City on the Differences in Prayer Times in Each District**

The city of Makassar is geographically located at coordinates approximately 5°08′–5°14′ South Latitude and 119°24′–119°32′ East Longitude, with diverse topography ranging from coastal areas to inland and hilly regions (BPS, 2023). The difference in prayer times between regions in the city of Makassar is influenced by variations in geographical location, particularly latitude and longitude. The further east or west a region is located, the more noticeable the time difference becomes, even if it's just a few minutes. The calculation of prayer times essentially involves determining the position of the sun based on predetermined criteria. The position of the sun varies from day to day due to the revolution of the Earth, which causes the apparent daily movement of the sun, allowing our prayer times to vary each day.[1] To determine the start of prayer times, astronomy uses two methods, one of which is the calculation method, also known as the reckoning method. In this calculation method, astronomy combines astronomy with mathematics, where astronomy provides the astronomical data needed for the calculation, while mathematics provides the precise formulas for the calculation (Kamiswidaryani, 2023). To demonstrate this, prayer times are calculated using calculation formulas based on contemporary spatial data. The research locations used are three mosques in the city of Makassar, namely Masjid Amirul Mukminin in Ujung Pandang District, Masjid Agung Baruga Antang in Manggala District, and Masjid Hj. Fatimah Mosque in Biringkanaya District, with the calculation date set for April 12, 2026.

**Initial Calculation of Prayer Times for Amirul Mukminin Mosque (Floating Mosque) in Ujung Pandang District**

1. The beginning of the time for the Zuhr prayer
   a. Data:
      Longitude of the location :119° 24’ 28.95’’
      Regional Longitude : 120° WITA
      EoT : -0° 0’ 51’’
   b. Formula for the Zuhr Prayer
   Mp + KWD + i

Mp = 12 – e = 12 – (-0° 0’ 51’’) = 12° 0’ 51’’

KWD = 120° - 119° 24’ 28,95’’ = 0° 35’ 31,05’’ : 15 =0° 2'22,07''12° 3'13,07''+
Ihtiyat =0° 2'12° 05'13,07''+

So, the start time for the Dhuhr prayer in Ujung Pandang District on April 12, 2026, is 12:05:13 WITA.

2. The beginning of the Asr prayer time
   a. Data
      Latitude (p) : -5° 8’ 48.08’’
      Longitude of the location : 119° 24’ 28.95’’
      Region longitude : 120° WITA
      Declination (d) : 8° 40’ 1’’
      EoT : -0° 0' 51''
   b. Formula for Asr Prayer
      Cotan h = tan (p – d ) + 1
      = tan (-5°8’48,08’’ - 8°40’1’’) + 1
      = tan 13° 48’ 49,04’’ + 1
      = 0,2458754640101 + 1
      = 1,2458754640101
      h = 38° 45’ 7,96’’

      Cos t = - tan p x tan d + sin h : cos p : cos d
      = - tan 5° 8’ 48,08’’ x tan 8° 40’ 1’’ + sin 38° 45’ 7,96’’ : cos -5° 8’ 48,08’’ : cos 8° 40’1’’
      t = 49° 29’ 52,33’’ : 15 = 3° 17’ 59,49''
      Mp = 12 – e = 12 – (-0° 0’ 51’’) =12° 0'51'' 15° 18'50,49''+
      KWD = 120° - 119° 24’ 28,95’’ = 0° 35’ 31,05’’ : 15 =0° 2'22,07''15° 21'12,56''+
      Ihtiyat =0° 2'15° 23'12,56''+

So, the start time for the Asr prayer in Ujung Pandang District on April 12, 2026, is 15:23:13 WITA.

3. The beginning time of Maghrib prayer
   a. Data
      Latitude (p) : -5° 8’ 48.08’’
      Longitude of the location : 119° 24’ 28.95’’
      Region longitude : 120° WITA
      Declination (d) : 8° 40’ 1’’

EoT : -0° 0' 51''
h : -1°

b. Formula for As Maghrib Prayer

Cos t = - tan p x tan d + sin h : cos p : cos d
= - tan 5° 8’ 48,08’’ x tan 8° 40’ 1’’ + sin -1° : cos -5° 8’ 48,08’’ : cos 8° 40’1’’

= -0,0039961653

t = 90° 13’ 44,27’’ : 15 = 6° 0’ 54,95''

Mp = 12 – e = 12 – (-0° 0’ 51’’) =12° 0' 51'' 18° 1' 45,95''+

KWD = 120° - 119° 24’ 28,95’’ = 0° 35’ 31,05’’ : 15 =0° 2'22,07''18° 4'8,02''+

Ihtiyat =0° 2'18° 06' 8,02''+

So, the start time for Maghrib prayer in Ujung Pandang District on April 12, 2026, is 18:06:08 WITA.

4. The beginning of the Isha prayer time

a. Data

Latitude (p) : -5° 8’ 48.08’’
Longitude of the location : 119° 24’ 28.95’’
Region longitude : 120° WITA
Declination (d) : 8° 40’ 1’’
EoT : -0° 0' 51''
h : -18°

b. Formula for As Isha Prayer

Cos t = - tan p x tan d + sin h : cos p : cos d
= - tan 5° 8’ 48,08’’ x tan 8° 40’ 1’’ + sin -18° : cos -5° 8’ 48,08’’ : cos 8° 40’1’’

= -0,3001224780583

t = 107° 27’ 53,85’’ : 15 = 7° 9’ 51,59''
Mp = 12 – e = 12 – (-0° 0’ 51’’) =12° 0' 51'' 19° 10' 42,59''+
KWD = 120° - 119° 24’ 28,95’’ = 0° 35’ 31,05’’ : 15 =0° 2'22,07''19° 13'4,66''+
Ihtiyat =0° 2'19° 15' 4,66''+

So, the start time for the Isha prayer in Ujung Pandang District on April 12, 2026, is 19:15:05 WITA.

5. The beginning time of the Fajr prayer

a. Data

Latitude (p) : -5° 8’ 48.08’’
Longitude of the location : 119° 24’ 28.95’’

Region longitude : 120° WITA
Declination (d) : 8° 40’ 1’’
EoT : -0° 0' 51''
h : -20°

b. Formula for As Fajr Prayer

Cos t = - tan p x tan d + sin h : cos p : cos d
= - tan 5° 8’ 48,08’’ x tan 8° 40’ 1’’ + sin -20° : cos -5° 8’ 48,08’’ : cos 8° 40’1’’
= -0,3336419835545
t = 109° 29’ 23,95’’ : 15 = 7° 17’ 57,59’’

Mp = 12 – e = 12 – (-0° 0’ 51’’) = 12° 0' 51''
The angle of the sun in the hour =7° 17' 57,59''4° 42' 53,41''-
KWD = 120° - 119° 24’ 28,95’’ = 0° 35’ 31,05’’ : 15 =0° 2'22,07''4° 45'15,48''+
Ihtiyat =0° 2'4° 47' 15,48''+

So, the start time for the Fajr prayer in Ujung Pandang District on April 12, 2026, is 04:47:16 WITA. By using the same calculation method at the three mosque locations, different prayer times were obtained according to their respective geographical positions. The differences are not too far apart, generally only in the range of seconds to one or two minutes, but they still show a significant impact from the variations in latitude and longitude. A summary of the differences in prayer times can be seen in the table below.

Table 1. The difference in prayer times based on the geographical position of three districts in Makassar City on April 12, 2026

| **Location** | **Prayer Schedule** | | | | |
|---|---|---|---|---|---|
| | **Subuh** | **Zuhur** | **Asar** | **Magrib** | **Isya** |
| Makassar City And Surroundings | 04:47:00 | 12:05:00 | 15:23:00 | 18:06:00 | 19:15:00 |
| Masjid Amirul Believers (District Ujung Pandang) | 04:47:16 | 12:05:13 | 15:23:13 | 18:06:08 | 19:15:04 |
| Great Mosque Bukit Baruga (Kecamatan Mangala) | 04:47:48 | 12:04:54 | 15:23:12 | 18:06:39 | 19:15:36 |
| Mosque Hj. Fatimah (Kecamatan Biringkanaya) | 04:46:45 | 12:04:44 | 15:23:10 | 18:05:42 | 19:14:39 |

*Source: Calculation results using contemporary hisab formula*

**The Utilization of QGIS Software in Visualizing and Presenting Prayer Times**

The use of Quantum Geographic Information System (QGIS) software in this research serves as an instrument to integrate astronomical prayer time data with precise geographic coordinates (latitude and longitude). Thru its vector-based projection engine, QGIS enables the visualization of the spatial distribution of prayer times thru isochronic mapping, which depicts uniform time lines within a specific area.

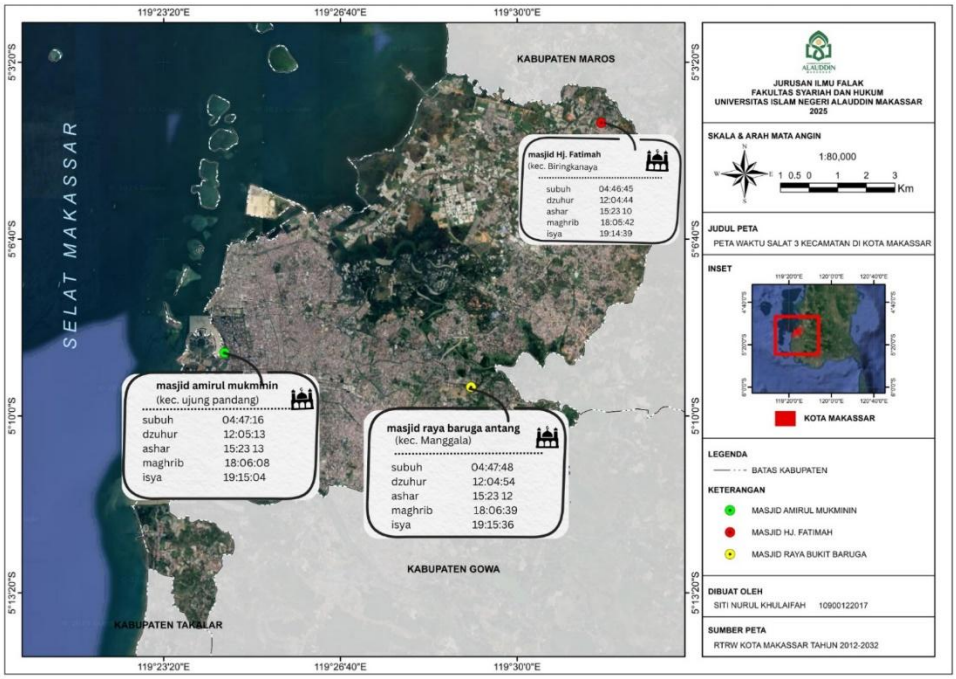



Figure 1. Visualization of prayer time differences in three districts of Makassar City based on geographical position

The visualization process is carried out by utilizing database management attributes that connect prayer time calculation algorithms with spatial entities. The final result is not merely a presentation of statistical cartography, but rather a spatial representation model that can comprehensively present variations in duration and transitions of prayer times, thereby facilitating the analysis of prayer time distribution patterns based on regional typology. QGIS as a tool for spatial analysis. The goal is to visualize the differences in prayer times at several points in the city of Makassar based on their respective geographical positions.

## CONCLUSION

This study demonstrates that prayer times in Makassar can be determined accurately through the integration of contemporary astronomical calculations and geographical coordinate data. The calculation process incorporates latitude, longitude, solar declination, the Equation of Time, and specific solar altitude criteria corresponding to each prayer. These parameters enable the beginning of prayer times to be calculated according to the apparent position of the Sun at each location.

The results also show that geographical position influences prayer-time variation within Makassar City. Analysis of three selected locations—Amirul Mukminin Mosque in Ujung Pandang District, Raya Bukit Baruga Mosque in Manggala District, and Hj. Fatimah Mosque in Biringkanaya District—revealed differences ranging from several seconds to approximately one minute. Although these variations are relatively small, they confirm that differences in latitude and longitude within the same urban area can still produce measurable differences in prayer times.

The application of QGIS proved effective for visualizing these spatial variations. Thematic maps generated through QGIS provide a clearer representation of prayer-time differences across locations than conventional tabular presentations. By integrating astronomical calculation with geospatial visualization, this study offers a practical approach to the development of digital Islamic astronomy and provides a basis for more location-sensitive presentation of prayer-time information.

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