Middle-East Journal of Scientific Research 20 (12): 2164-2171, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.20.12.21115

Malaysian Observatories and Those of the Islamic Civilization Era: General Similarities

[1]*Mohd Hafiz Safiai,* [2]*Ezad Azraai Jamsari and* [1,3]*Ibnor Azli Ibrahim*

[1]Institute of Islam Hadhari, Universiti Kebangsaan Malaysia,43600 UKM Bangi, Selangor, Malaysia
[2]Department of Arabic Studies and Islamic Civilization, Faculty of Islamic Studies,
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia
[3]Department of Syariah, Faculty of Islamic Studies,
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

Abstract: Observatories were first built to observe celestial objects such as stars and planets and to record their movement and they eventually become centres and institutions for research and education. The history of Malaysian observatories began in the early years of the 1980's with the construction of an observatory, built and systematically administered by the government for the purpose of research, education and tourism. This article discusses a study on the similarities between the Malaysian observatories and those built during the Islamic civilization era. The objective of this study was to analyze the general similarities between the two sets of observatories. A qualitative method was used in this study via instrument observation, interviews and document analyzes. The result of this study argues that all Malaysian astrofiqh observatories share specific similarities with their counterparts built during the Islamic civilization era encompassing a multitude of aspects, as in the establishment aims, landscape, instruments and name designation of observatories.

Key words: Observatory · Islamic astronomy · Astrofiqh · Cosmofiqh · Islamic civilization

INTRODUCTION

Previous studies have discussed the role of Islamic civilisation in influencing present-day technology [1-3]. In the study of astronomy, obsevatories have long been an important scientific institution. In the early days of their history, observatories were built as a site for observing celestial objects such as the moon, stars and planets. Observations were made to record data on the movement and location of those objects in order to study and understand their physical nature. Later on, the function of observatories evolved into becoming research sites. In the Islamic world , research were carried out for the development of astronomy studies, especially in matters concerning worship rituals in an Islamic society such as determining the qiblah direction and calculating the exact prayer times. At the same time, observatories also function as education centres. Through the institutionalization of observatories, the general society is exposed to the sciences of astronomy and interests in the studies of astronomy are generated.

The current study embarked upon previous work such as 'Kepentingan Balai Cerap dalam Penyelidikan Astronomi (The Importance of Observatories in Astronomy)' by Othman [4], 'Kompleks Falak al-Khawarizmi: Perancangan dan Hala Tuju (The al-Khawarizmi Astronomy Complex: Planning and Future Direction)' by Bahali [5], 'Balai Cerap: Dulu hingga Kini (Observatories: Then and Now)' by Abdul Aziz [6], 'Peranan Institusi Balai Cerap dalam Pembangunan Ketamadunan Islam: Satu Sorotan (The Role of Observatory Institutions in the Development of Islamic Civilization: A Highlight)' by Ismail et al. [7] and 'Hala Tuju Balai Cerap di Malaysia (Future Direction of Observatories in Malaysia)' by Zainuddin [8]. As a matter of fact, a study by Ibrahim *et al*. [9] has even holistically

Corresponding Author: Ezad Azraai Jamsari, Department of Arabic Studies and Islamic Civilization,
Faculty of Islamic Studies, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia.
Tel: +60389215291, Fax: +60389213185.

showcased an observatory in Malaysia, namely the al-Khawarizmi Astronomy Complex from the angle of its precision construction as an education and research friendly observatory. The study found that the astronomy complex has been playing an important role in providing various facilities which are complete, modern and sophisticated, precisely meeting the purpose of its establishment as an education and research friendly observatory. Hence, the objective of this study is to analyze the general similarities between the Malaysian astrofiqh observatories and those of the Islamic civilization era.

Observatories in Islamic Civilization: The science of astronomy has long been in existence in Islamic civilization. The middle period of Islamic civilization era, in particular early in the 9th century during the Abbasid rule of Caliph al-Ma'mun (813-833), witnessed the rapid progress in the field of astronomy. In the same century, the first Islamic observatory was built in Baghdad, known as the Shammasiyyah Observatory. The observatory was constructed during the era of al-Ma'mun's rule and become operational in the year of 828 [10]. Astronomical observation activities were done to obtain information on heavenly bodies, either for the learning of astronomy or for astrological purposes. The observation activities were continually done and were, at that time, necessary in order to obtain an accurate account of the celestial objects. Hence, the establishment of observatories was an effective effort to enhance the progress of astronomy during that period of time. Ultimately, observatories became one of the most important scientific institutions in the history of Islamic civilization [11, 12].

In general, there are two kinds of observatories in Islamic civilization; which are (a) observatories which also served as education institutions; and (b) those which had the sole purpose of astronomical observation. Observatories which functioned as education institutions were equipped with facilities fit for academic activities in the study of astronomy, complete with housing areas and amenities for astronomers to carry out their field and group research work [13]. An example of such observatory is the Malikshah Observatory, which was built by the third Seljuk sultan, Malikshah, around the 11th century. It was the first 'sultan-owned' observatory ever to serve as an academic institution. The exact location of this observatory, however, was not known as there are a few places which are believed to be its site; they are Nishapur, Rayy, Marw and Isfahan [14]. Another observatory included in this category is the al-Afdal al-Bataihi Observatory which is located in Cairo, Egypt. This observatory was completed in 1125 during the rule of Caliph al-Amir bin Ahkam Allah (1101-1130) of the Fatimid Kingdom [15].

Marni and Haron [13] outlined the second type of observatory as one that did not serve as an education institute for not having the facilities necessary to play the role as one. An example of this type of observatory is the Sharaf al-Dawlah observatory which was built by a Banu Buwayh ruler, Sharaf al-Dawlah (982-989), within the compound of his castle in Baghdad. Virk [15] mentioned that among the activities done at the observatory were studies on planetary positions of the solar system, solstis and equinox as well as solar studies. Another example is the Ibn al-'Amid observatory, located in Rayy which was built by Ibn al-'Amid, a *wazir* who served Rukn al-Dawlah for about 32 years [14].

However, there were two observatories which were the pinnacle in the history of astronomy in Islamic civilization, leaving a lasting legacy. They are the Maragheh Observatory and the Ulugh Beg Observatory. Being categorized as the first type of observatory, both observatories were built complete with up-to-date facilities for astronomers to carry out their research work as well as amenities for the education and learning of astronomy. At the height of operation, the two observatories possessed the most sophisticated equipment at that time and provided efficient programs for the study of astronomy, employing numerous astronomers and mathematicians.

The Maragheh Observatory: The Maragheh Observatory was the brainchild of Hulagu Khan and his brother Mangu Khan. It was them who directed Nasir al-Din al-Tusi to head and oversee the construction of the observatory [16]. Some studies suggested that it was Nasir al-Din al-Tusi himself who initiated the idea of its construction and he, later on, proposed the idea to Hulagu Khan to build it.

The Maragheh Observatory was located on a hilltop in the suburb of Maragheh in Azerbaijan [17]. Its constrction process commenced in 1259 and took five years to complete. Although located at the hilltop, water supply was not an issue, as it was made available by special tool and a water mill. Other amenities included a mosque and a library which housed more than 400,000 books. Its high altitude made it a strategic position and the existence of a befitting dome made it suitable to carry out astronomic observation. Apart from that, a special residence for Hulagu Khan was also built on the same hill [18].

The observatory was active and operational for about 53 years even after the death of Hulagu Khan in the year 1265. Due to the sheer number of astronomers and the complete facilities such as the huge library, this observatory was considered as a model for later observatories, having an apt characteristics as an institution of science which provided ample space and opportunities for astronomers to exchange ideas and information.

The highest achievement made at the observatory was the devising of the Ilkhanic Tables, also known as Zij Ilkhani in Persian. The book was a compilation of astronomical tables of planetary movements. In the year 1336, the Maragheh Observatory which had been in operation for more than 50 years ceased to operate as a result of the downfall of the Il-Khan kingdom in 1339 [19].

The Ulugh Beg Observatory: The Ulugh Beg Observatory was built by Muhammad Turgay Ulugh (1394-1449) who was more famously known as Ulugh Beg. He was born in Sultaniyeh, a town in Azerbaijan. The construction of the observatory was Ulugh Beg's own initiative due to his keen interest in the study of mathematics and astronomy [20]. The observatory was modeled after the Maragheh Observatory. Several scientists have been directed to prepare building plans of the observatory, Ghiyath al-Din Jamshid dan Mu□in al-Dini Kashi being among them. This observatory was built on a hill in the outskirt of Sultaniyeh and was equipped with facilities and up-to-date instruments [21]. The construction process commenced in 1420 and the observatory became operational about a year later in 1421. Ulugh Beg invited many scientists to work at the observatory with the hope of making Samarqand a centre for the studies of mathematics and astronomy. Among them were Salah al-Din Qadizada, 'Ala al-Din 'Ali Qushji dan Mu'ayyad al-Din al-Urdi [14].

The advancement of knowledge at that time necessitated the establishment of observatories. The erection of the Ulugh Beg Observatory was a crown achievement during his rule in the history of the Islamic world's observatory establishment [22]. Other achievements included the creation of star tables and charts and astronomical catalogues as a result of the work of Ulugh Beg and his fellow scientists at the observatory. The observatory remained operational for more than 30 years under his rule [23] until a few years after the demise of Ulugh Beg who was killed by his own son, Abd al-Latif, in the year of 1450 [24].

Astrofiqh Observatories in Malaysia: The Malaysian society has long been influenced by the study of astronomy, even before the establishment of observatories in Malaysia. Due to the society's keen interest and their needs of the time, observation of celestial bodies were done traditionally on minarets and hills. Equipment used was basic and handheld such as binoculars, telescopes and theodolites which were easy to carry around. The observation activities were carried out to observe the moon crescent for the determination of the start of important months in the Islamic calendar, especially Ramadan, Shawal and Zul Hijjah, which are associated with fasting and the Muslim celebrations.

Up to date, there are five main astrofiqh observatories in Malaysia; namely *Pusat Falak Sheikh Tahir* (the Sheikh Tahir Astronomy Centre) in the state of Pulau Pinang, *Kompleks Falak al-Khawarizmi* (the al-Khawarizmi Astronomy Complex) in the state of Melaka, the al-Biruni Observatory in Sabah, the Selangor Observatory and *Kompleks Baitulhilal Teluk Kemang* (Teluk Kemang Baitulhilal Complex) in Negeri Sembilan. All observatories are administered by the respective State Mufti Department. The history of astrofiqh observatories in Malaysia began in the 1980's with the establishment of Pusat Falak Sheikh Tahir which was built in 1988 and officially opened on October 9th, 1991. The building of the observatory was in fact a starting point for the advancement of astronomic sciences in Malaysia. The observatory serves as a research station for astronomic and atmospheric sciences and is currently run together by the Pulau Pinang State Mufti Department and the Astronomy and Atmospheric Science Research Unit of the Universiti Sains Malaysia (University of Science, Malaysia) [25].

The Sheikh Tahir Astronomy Centre is located in Pantai Acheh, the westernmost area on the island of Pulau Pinang. The position coordinates of the observatory is at a latitude of 5º 24' 44" N and a longitude of 100º 11' 52" E. It was built on a hill at an altitude of 40 m above sea level. Its position which is far away from the hustle and bustle of the city makes it an ideal location for astronomic observation [26].

The al-Khawarizmi Astronomy Complex in the state of Melaka was built in 2002 and was officially opened on December 1st 2007. The suggestion to build this observatory was brought about so as to widen the scope of and facilitate administration matters pertaining to Islamic worship and rituals such as determination of the beginning of the month in the Muslim calendar and the determination of prayer times [27]. The observatory

complex is located in Kampung Balik Batu, Tanjung Bidara in the district of Alor Gajah, about 25 km from the Historical City of Malacca. It is situated at the shore facing the Straits of Malacca, at a latitude of 02°17' 39" N dan longitud 102°05' 06" E. The observatory was built to face the direction of the qiblah with an azimuth of 292°52' 22" [5].

Next to be built was the al-Biruni Observatory in Sabah in the year 2004. The installation of the observatory was not only for the purpose of the annual *hilal* observation but also served as a catalyst for growth in the sector of astronomy education, research and tourism. Officially opened on 29th October 2007, this observatory has been playing an important role in the growth of astronomy science in the state of Sabah, specifically and in Malaysia, generally [28]. The al-Biruni Observatory is sited at Tanjung Dumpil, Putatan about 15 km from the state capital Kota Kinabalu. The coordinate position of this observatory is at a latitude of 05°54' 18" N and a longitude of 116°02' 09" E. At an altitude of 1.7 m above sea level, this observatory faces the South China Sea and sits parallel with the direction of the qiblah at an azimuth of 290°22' 31". Besides, it has a wide angle view of the western horizon, at azimuths 230º-310º [28].

The building of astrofiqh observatories in Malaysia flourished further in 2009 with the installation of the Selangor Observatory which started to run officially on 20th July 2009. Run by the Mufti Department of the State of Selangor, its establishment is aimed at becoming a research and education centre for the study of Islamic astronomy while at the same time acting as a medium for proselytizing Islamic teachings to the public. On top of that, it was hoped that the site becomes a tourist attraction for the district of Sabak Bernam [29]. The Selangor Observatory is located in Sungai Lang, which is about 20 km away from the town of Sabak Bernam. It has an area of approximately 4824 m^2 within an area of 100 acres of the Pusat Dakwah Islamiah. The observatory is at the geographical coordinates of latitude 03°49' 09" N and longitude 100°48' 57" E. The positioning of the observatory, at 7 m above sea level and facing the Straits of Malacca, gives a horizon view which was wide and strategic, unobstructed by any object and ideal for *hilal* sighting activities [30].

The fifth observatory installation in Malaysia was the Teluk Kemang Baitulhilal Complex in the state of Negeri Sembilan. The complex started off as an ordinary observatory station for *hilal* sighting. Later on in December 2009, refurnishment and upgrading work were done at the observatory and completed in November 2011. Four months later the complex started to operate again, this time under the administration of the State Mufti Department of Negeri Sembilan in cooperation with the University of Malaya [31]. This latest observatory is about 40 km away from the state capital of Seremban and was built on the sea shore facing the Straits of Malacca at these coordinates: latitude 02°26' 44" N and longitude 101°51' 21" E. Like other observatories in Malaysia, this complex was so built as to face the qiblah at an azimuth of 292°52' 22"[32].

The Teluk Kemang Baitulhilal Complex was built in a 1.2 hectare land area owned by *Majlis Agama Islam Negeri Sembilan* (MAINS, the Islamic Religious Council of Negeri Sembilan). The complex cost about MYR30 million to build and it was a collaboration work between MAINS and *Jabatan Wakaf, Zakat dan Haji* (JAWHAR, the Department of Waqaf, Zakat and Hajj) [33]. This complex is well equipped with the most sophisticated telescope in Southeast Asia costing MYR1.8 million [34].

The establishment of astrofiqh observatories in Malaysia has been enhancing the advancement of astronomic studies in the country. Apart from functioning as a site for observation activities, the observatories also play an active and effective role as research and education centres for the studies of Islamic astronomy in particular in matters concerning Muslim worship. In general, all observatories in Malaysia are built with the aim of developing the field of astronomy through research, education and even tourism.

General Similarities between the Astrofiqh Observatories in Malaysia and Those of the Islamic Civilization Era: History proved that earliest establishment of observatory occurred during the Islamic civilization era in West Asia or the Middle East. The ideas of building observatories were initiated by by the scientists of that time to carry out their work. The initiatives were usually taken up by the governing rulers of that time who directed the construction of the observatories. All these were done out of their keen interest in the quest for knowledge particularly in the field of astronomy, leading to the advancement of the science of astronomy of that time. The effort of building observatories did not stop then but flourished to Europe and throughout the world.

Up to date, Malaysia has five official astrofiqh observatories which are administered systematically. There are several general similarities between the Malaysian observatories and their counterparts of medieval Islamic age. The following aspects describe them:

Aim of Establishment: The first general similarity can be seen through the aspect of the aim and objective of establishing or setting up the observatories. They have been set up to, first and foremost, to fulfill the need of worships and routine rituals of the Muslims such as determining the exact prayer times, direction of the qiblah and the start of the months of Ramadhan, Shawwal and Zul Hijjah by *hilal* sighting [35]. The astronomical calculation to determine those is based upon the motion of heavenly bodies such as the sun, stars and the moon relative to the position of the observer on earth. The prayer times are, therefore, different and change on a daily basis depending on the location [36]. Next to be determined is the direction of the qiblah which is the focal point all Muslims in the world as Muslims need to face the Kaabah which is located in Mecca in order to perform their prayers. There are various techniques to ascertain the qiblah direction, either by using traditional methods like the use of the star al-Qutbi (Polaris) and sun crossing or by using modern methods such as the use of compass and theodolite [37]. Finally, *hilal* observation is made in order to determine the start of the month in the Islamic calendar. In Islamic calendar system, sighting the *hilal*, called *rukyah*, is the main method of determining the start of the month. *Rukyah* is by definition is to sight the *hilal* after sunset while *hilal* is defined as the crescent moon after the first *ijtima'* (conjunction) which is sometimes seen after sunset [38].

Name Designation: From the aspect of name designation or naming the observatory, both sets of observatories follow the same pattern. Observatories of the Islamic golden era, like the Malikshah Observatory, the Sharaf al-Dawlah Observatory and the Ibn al-'Amid Observatory, were named after famous figures. This idea is used in Malaysia as obviously seen in the name designation of the observatories such as *Pusat Falak Sheikh Tahir* (the Sheikh Tahir Astronomy Centre) in the state of Pulau Pinang, *Kompleks Falak al-Khawarizmi* (the al-Khawarizmi Astronomy Complex) in the state of Melaka and the al-Biruni Observatory in Sabah. All those were named after well-known astronomers.

The Sheikh Tahir Astronomy Centre was named after an authoritive figure in the field of astronomy in the Malay archipelago. His full name was Muhammad Tahir bin Syeikh Muhammad. He was also known with the title Sheikh Muhammad Tahir Jalaluddin al-Falaki al-Azhari. An example of his great work is the *Natijat al-'Umur* which discussed the calculation to determine the Hijri and Gregorian calendar, *qiblah* direction and prayer times [39, 40].

The al-Khawarizmi Astronomy Complex, meanwhile, was named after al-Khwarizmi, the great mathematician, astronomer and historian in the House of Wisdom, Baghdad. His full name was Abu 'Abd Allah Muhammad ibn Musa al-Khawarizmi. He was considered one of the world's greatest mathematicians, pioneering fundamental and important concepts in mathematics. Algebra is a testament to his great contribution to the world in the field of mathematics. Among great work by him is the book *al-Kitab al-Mukhtasar fi Hisab al-Jabr wa al-Muqabalah* which introduced and discussed the algebraic question [41].

Undoubtedly, the al-Biruni Observatory was named after a great figure and scholar in the field of mathematics, geography, physics and astronomy. His full name was Abu Rayhan Muhammad bin Ahmad al-Biruni, a Muslim scholarly figure with a vast knowledge in many sciences, especially astronomy. His greatest achievement was authorship of a famous book namely Qanun al-Mas?udi which encompassed several fields of knowledge such as astronomy, geography and mathematics. The book introduced astronomical glossary of terms and discussed earth's movement in its orbit and other celestial objects [42].

Landscape: The next general similarity of the two sets of observatories exists in the perspective of landscape positioning. Many, if not most, observatories in Malaysia are built at a high location giving them a wide view of the horizon, a concept similar to that behind observatory construction of medieval Islamic times. The high altitude facilitates astronomic observation activities to obtain accurate results unobstructed by objects such as trees and buildings. Besides, their locations next to the seashore give a wide view of the horizon. Even though the two sets of observatories are of different locations, the concepts behind them are however the same. This shows that there are certain characteristics of the historical observatories which influence astrofiqh observatories in Malaysia.

Instruments: The final general similarity which can be observed between astrofiqh observatories of Malaysia and those of medieval Islam is in the instrument. The Malaysian observatories possess and still use traditional astronomy instrument, much alike those used in medieval Islamic times such as rubu' mujayyab, sundials and astrolabes. The existence of those tools, still being used today or made artefacts or monuments at the observatories, is aimed at reliving a past legacy of the

Islamic civilization. In addition to that, procedures on how to use such instrument are also taught to the public in seminars, courses and educational workshops run by the Malaysian astrofiqh observatory institutions in an effort to revive the past glory of Islamic civilization [43].

CONCLUSION

The establishment of observatories has long occurred beginning in the Islamic civilization ages and has not stopped since then. In fact, its establishment is spread throughout the Islamic world and follows the changes of time. The first of the five general similarities between the astrofiqh observatories in Malaysia and those of the Islamic civilization era can be seen through the aspect of the aims of the observatory establishment which was to fulfill the need for an accurate determination of times, dates pertaining to Islamic rituals and worship such as *salah*, Ramadan, Shawal and Zul Hijjah and the direction of *qiblah*. Next, the second similarity between the two sets of observatories can be found in that the observatories were named after personalities of important significance. In addition to this, the third similarity is seen through the aspect of landscape position of the observatories whereby they are located at high lands having a wide view of the sky horizons. This enables observation activities to be carried out without any hindrance. The final similarity can be observed in the aspect of tools and equipment at the observatories. Many of those used during the Islamic Golden Age still exist until today either still being used or made as artefacts or monuments. These similarities indirectly prove that the building of the Malaysian astrofiqh observatories has been influenced by those of the Islamic golden era.

ACKNOWLEDGEMENT

This study is financed by the Research Group of Islamic Military History (SAKTI: INDUSTRI-2012-006 & PTS-2011-106), UKM; the Action/Strategic Research Group on the Astrofiqh and Cosmofiqh (PTS-2012-124), UKM; the Research Group of Arabic Culture and Islamic Civilization (KUKAPI), UKM; the Research Group of Modelling Interaction Between Civilizations (FRGS/1/2012/SSI05/UKM/02/1), the Ministry of Education; and the Research Group of West Asian Region Studies (AKRAB), UKM.

REFERENCES

1. Al-Hassani, S., 2006. 1001 Inventions: Muslim Heritage in Our World. Manchester: Foundation of Science, Technology and Civilization. http://www.1001inventions.com/
2. Sidik, R. and J. Abu Bakar, 2012. Al-Khawarizmi: Leading Contributor to Indigenization of Science in the Islamic Civilization. Advances in Natural and Applied Sciences, 6(3): 324-330. http://www.aensiweb.com/anas/2012/324-330.pdf
3. Jamsari, E.A., M.A. Mohd Nawi, A. Sulaiman, R. Sidik, Z. Zaidi and M.Z.A.H. Ashari, 2013. Ibn Firnas and His Contribution to the Aviation Technology of the World. Advances in Natural and Applied Sciences, 7(1): 74-78. http://www.aensiweb.com/anas/2013/74-78.pdf
4. Othman, M., 1993. Kepentingan Balai Cerap dalam Penyelidikan Astronomi [The Importance of Observatory in Astronomy Research]. Paper presented in the 1993 National-level Astronomy Seminar, pp: 1.
5. Bahali, K., 2006a. Kompleks Falak Al-Khawarizmi: Perancangan dan Hala Tuju [Al-Khawarizmi Astronomy Complex: Planning and Future Direction]. Paper presented at the 2006 Seminar on Appreciating Asronomy, pp: 14.
6. Abdul Aziz, A.H., 2010. Teknologi Balai Cerap: Dulu hingga Kini [Observatory Technology: Then and Now]. In the Proceedings of the 2010 Pan-Malaysian Conference on Future Directions of Observatories, pp: 1.
7. Ismail, K., M.S.A.M. Nawawi, M.S.M. Yusuf and M.A. Niri, 2008. Peranan Institusi Balai Cerap dalam Pembangunan Ketamadunan Islam: Satu Sorotan [The Role of Observatory Institutions in the Development of Islamic Civilization: A Highlight]. Paper presented at the National Seminar on the Excellence of Islamic Civilization in Agriculture, Science and Technology, pp: 1.
8. Zainuddin, M.Z., 2010. Future Direction of the Observatories in Malaysia. In the Proceedings of the 2010 Pan-Malaysian Conference on Future Directions of Observatories, pp: 1.
9. Ibrahim, I.A., M.R. Ahmad, M.H. Safiai and W.K. Mujani, 2012. Islamic Astronomy and the Establishment of al-Khawarizmi Complex in Malaysia. Advances in Natural and Applied Sciences, 6(3): 316-320. http://www.aensiweb.com/anas/2012/316-320.pdf

10. Ibn Sa'id al-Andalusi, Abu al-Qasim Sa'id bin Ahmad, 1912. Tabaqat al-Umam [Categories of Nations]. Beirut: Impremerie Catholique, pp: 50.
11. Mujani, W.K., I.A. Ibrahim and M.H. Safiai, 2012. Observatories in Islamic History. Advances in Natural and Applied Sciences, 6(8): 1370-1373. www.aensiweb.com/anas/2012/1370-1373.pdf
12. Kaviani, R., N. Salehi, A.Z.B. Ibrahim, M.R.M. Nor, F.A.F.A. Hamid, N. Hamzah and A. Yusof, 2012. The Significance of *Bayt Al-Hikma* (House of Wisdom) in Early Abbasid Caliphate (132A.H-218A.H). Middle-East Journal of Scientific Research, 11(9): 1272-1277. http://idosi.org/mejsr/mejsr11(9)12/17.pdf
13. Marni, N. and Z. Haron, 2008. Institusi Pengajian Syariah & Sains: Era Kegemilangan Tamadun Islam [Syariah and Scientific Studies Institutions: The Golden Era of Islamic Civilization]. Skudai: Penerbit Universiti Teknologi Malaysia Press, pp: 78.
14. Sayili, A., 1960. The Observatory in Islam and Its Place in the General History of the Observatory. Ankara: Publications of the Turkish Historical Society, pp: 161-162.
15. Virk, Z., 2010. A Brief History of Observatories in the Islamic World. In Review of Religions, Ed., Hayat, Rafiq. London: Islamic Publications, pp: 46-63.
16. Goldstein, B.R., 1985. Theory and Observation in Ancient and Medieval Astronomy. London: Variorum Reprints, pp: 101.
17. Krisciunas, K., 1999. Observatories, pp: 1-5. http://arxiv.org/PS_cache/astro-ph/pdf/9902/9902030v2.pdf
18. Ahmad, I., 1992. Signs in the Heavens: A Muslim Astronomer's Perspective on Religion and Science. Maryland: Writers' Inc. International, pp: 79-80.
19. Zaimeche, S., 2002. A Cursory Review of Muslim Observatories. Manchester: Foundation for Science Technology and Civilisation, pp: 2-3. http://www.muslimheritage.com/uploads/ACF25AE.pdf
20. Ayduz, S., 2008. Ottoman Contributions to Science and Technology: Examples from Geography and Astronomy. Manchester: Foundation for Science Technology and Civilisation, pp: 1-3 http://muslimheritage.com/topics/default.cfm?ArticleID=982
21. Krisciunas, K., 1992. The legacy of Ulugh Begh. In Bulletin of the Association for the Advancement of Central Asian Research (AACAR), Ed., Parksoy, H.B., 5(1): 5-19. http://vlib.iue.it/carrie/texts/carrie_books/paksoy-4/5-1.html
22. Sayili, A., 2004. Turkish Contributions to Scientific Work in Islam. Manchester: Foundation for Science Technology and Civilisation, pp: 11-12. http://www.muslimheritage.com/uploads/TurkishScience.pdf
23. Heidarzadeh, T., 2010. Islamic astronomy. In Heritage Sites of Astronomy and Archaeoastronomy in the Context of the UNESCO World Heritage Convention: A Thematic Study, Eds., Ruggles, C. & M., Cotte. Paris: International Council on Monuments and Sites (ICOMOS), pp: 155-168. http://www.astronomicalheritage.org/images/content/astroherit/WHC-internal/ch10all.pdf
24. Hobden, H., 1999. Ulughbek and His Observatory in Samarkand. Lincoln: The Cosmik Elk, pp: 12-13.
25. Ilyas, M., 2003. Astronomi Islam dan Perkembangan Sains: Kegemilangan Masa Lalu Cabaran Masa Depan [Islamic Astronomy and Scientific Progress: Past Glories are Future Challenges]. Kuala Lumpur: Utusan Publications & Distributors Sdn. Bhd, pp: 120.
26. Observatori Negara Langkawi, 2009. Galeria Astronomi-Observatori Malaysia [Malaysian Astronomy-Observatory Galleria]. Putrajaya: Agensi Angkasa Negara (ANGKASA, National Space Agency), pp: 40.
27. Bahali, K., 2012. Sejarah pembinaan Kompleks Falak Al-Khawarizmi Melaka [History of Malacca's al-Khawarizmi Astronomy Complex Construction]. Interview, 5 March.
28. Abd. Rajak, M.J., 2011. Balai cerap al-Biruni negeri Sabah dan unit falak syar'ie pejabat mufti negeri Sabah: Peranan dan sumbangannya [The al-Biruni Observatory of Sabah and the Falak Syar'ie Unit of the Sabah Mufti Office: Roles and contributions], B. A. thesis, Universiti Kebangsaan Malaysia, Bangi, Selangor.
29. Jabatan Mufti Negeri Selangor. 2011. General Information. http://www.muftiselangor.gov.my/BalaiCerapSelangor/2maklumat.html
30. Jabatan Mufti Negeri Selangor. 2003. Kertas cadangan pembinaan Balai Cerap Selangor di Sungai Lang, Parit Baru, Sabak Bernam, Selangor [A proposal for the building of Selangor Observatory at Sungai Lang, Parit Baru, Sabak Bernam, Selangor], pp: 1-5.
31. Anon, 2010. MAINS ceburi bidang perhotelan [MAINS involvment in the hotel sector]. Arkib Utusan Malaysia. http://www.utusan.com.my/utusan/info.asp?y=2010&dt=0925&pub=Utusan_Malaysia&sec=Korporat&pg=ko_03.htm
32. Jabatan Kemajuan Islam Malaysia (JAKIM) Malaysian Department of Islamic Development, 2012. Koordinat tempat cerapan rasmi di Malaysia [Coordinates of official moonsighting sites in Malaysia]. http://www.islam.gov.my/e-falak/tempat-cerapan.

33. Jabatan Wakaf, Zakat dan Haji (JAWHAR), 2011. Melihat anak bulan ramadhan di kompleks baitulhilal tercanggih di Asia [Observing the Ramadhan crescent at Asia's most sophisticated baitulhilal complex]. http://jawhar.gov.my/index.php?option=com_content&view=article&id=665:melihat-anak-bulan-ramadhan-di-kompleks-baitul-hilal-tercanggih-diasia&catid=39:beritajabatan&Itemid=62&lang=ar
34. Anon, 2012. Balai cerap kompleks baitulhilal miliki teleskop tercanggih di Asia Tenggara [South East Asia's most sophisticated telescope owned by the baitulhilal complex observatory]. Berita Wilayah. http://www.bernama.com/bernama/v6/newsindex.php?id=659553
35. Nawawi, M.S.A.M., M.Z. Zainuddin, N. Ahmad, M.A. Niri, S. Man, R.A. Wahab, K. Ismail and N.H.A. Zaki, 2012. Application of Scientific Approach to Determine Lunar Crescent's Visibility. Middle-East Journal of Scientific Research, 12(1): 96-100. http://idosi.org/mejsr/mejsr12(1)12/17.pdf
36. Mahmud, M., 2006. Prayer time calculator. Final year project report, Faculty of Electronic and Computer Engineering, Universiti Teknikal Melaka, pp: 19-20.
37. Mohamed, A., 2006. Perisian Interaktif Percuma untuk Menentukan Arah Kiblat bagi Bandar Acheh melalui Kaedah Lintasan Matahari [Free Interative Software to Determine the Qiblah Direction for Bandar Acheh Using the Method of Solar Path]. In the Proceedings of the International Conference on Acheh Development, pp: 157-171.
38. Bahali, K., 2006. Penentuan Bulan-bulan Islam secara Rukyah dan Hisab [Determination of the Start of Islamic Months through *Rukyah* and *Hisab*]. Paper presented at the 1427H Appreciation of Ramadhan Seminar, pp: 3.
39. Jalaluddin, S.T., 1936. Natijat al-'Umur. Pulau Pinang: Penang Primier Press, pp: 1.
40. Man, S., M.Z. Zainuddin, M.R.M. Nor, M.A. Ramli, M.A.A. Rahim, R. Ramli and R. Ahmad, 2012. The Development of Islamic Astronomy Studies in Higher Learning Institutions in Malaysia. Middle-East Journal of Scientific Research, 12(1): 108-113. http://idosi.org/mejsr/mejsr12(1)12/19.pdf
41. Rahman, M.I., 1983. Muslim Contribution to Geography. In the Proceedings of the International Conference on Science in Islamic Polity, pp: 174.
42. Glick, T.F., S.J. Livesey and F. Wallis, 2005. Medieval Science, Technology and Medicine: An Encyclopedia. New York: Taylor & Francis Group, pp: 90.
43. Niri, M.A., M.Z. Zainuddin, S. Man, M.S.A.M. Nawawi, R.A. Wahab, K. Ismail, N.H.A. Zaki, A.A. Ghani and M.A.A. Lokman, 2012. Astronomical Determinations for the Beginning Prayer Time of Isha'. Middle-East Journal of Scientific Research, 12(1): 101-107. http://idosi.org/mejsr/mejsr12(1)12/18.pdf