COMPARATIVE STUDY OF MIZWALA AND ISTIWA'AINI AS QIBLA FINDER

THESIS

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UIN WALISONGO

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MOTTO

"We revealed to Moses and his brother: "Build for your people houses to dwell in Egypt, and make your houses a kiblah (places of worship) and keep up the prayer and give glad tidings to the believers. (Yunus:87)."

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My sincerity

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PREFACE

Praise and deep gratitude to Allah SWT for the abundance of grace , and guidance of Him given to the writer which has made this thesis can be completed properly. Greeting and Shalawat may always be devoted to the Prophet Muhammad . ﷺ

The thesis entitled ,“ ***Comparative study of Mizwala and Istiwa’aini as Qibla Finder ”*** as the last assignment for my Undergraduate study in Law and Syariah Faculty of UIN Walisongo Semarang.

I would like to express my gratitude to my beloved Mother ; Endang Purwanti, Father; Sudaryo, and Sister ; Sinta Dwi Anggraini for the eternal pray, love, patience, and all supports. To my supervisor Bapak Dr. Agus Nurhadi MA, thank you for the great patience, guidance, motivation, and contribution in finishing my thesis. May Allah always bless us and our family.

I also would like to express my deep gratitude to my super amazing angels, Suliman Qayumi, Martin Veskilt, Anisa Yuliani, Kharolin Hilda Amazona, and Kelvin. May Allah always bless us and we will be able to reach every dream we have, amin.

I have realized this thesis is so far from being outstanding. Therefore, I invite you as the readers to give comments and suggestions from those who are deeply concerned in such topic. However I expect this thesis will give worthwhile contributions to all readers.

Semarang, December, 24 2021

Lusiana Dwi Ariani

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ABSTRACT

Facing Qibla (Kaaba in Mecca) and getting the correct direction of it are the obligations which every Muslim need to do when they are performing salah. So it is truly important for them to learn how to determine the qibla properly correctly so that they will be able to find out the it easily wherever they are. Finding out the Qibla is not hard to do because there are many classic and modern astronomical instruments which have the function as Qibla Finder but it is for sure we will not be able to use them if we do not learn how to operate those instruments properly. People are also confused to choose which tool is the most accurate and simple one to use because there are too many qibla finders which are created. So on this opportunity the researcher have made the limitation for the qibla finder which would have discussed, those are Mizwala and Istiwa'aini. They have many similarities but totally different that is why the researcher are interested in doing research about them.

The research is quantitative which uses field research. The data is obtained from some sources and direct measurement at field. Considering that it is a field research so it has two types of data, those are primary source and secondary source. The primary source is the result of the astronomical calculations and measurements to determine the qibla direction using Mizwala and Istiwa'aini. Then the Secondary data is obtained from books, articles, and journals which explain about qibla direction. The methods of data collection are interview, observation and documentation. Then for for the methods of data analysis, the researcher uses a qualitative research method using descriptive approach and comparative.

The location for the research was in Masjid Al-Ikhlas, BPI, Ngaliyan, Central Java by the data, Latitude (ϕ^x) = 6°59'35", Longitude of place (λ^x)= 110°21'12", Longitude (λ^d)=105° (Wib), Measurement Time (WD)=14.00, Declination At the time of measurement (δ)= 23°56'17", Equation of time (e)=0m 3d. The research was conducted in the beginning of 2020 for two times (2 days) at 14.00 WIB everyday . The instruments used were Mizwala and Istiwa'aini.

The result of the research has shown that there is no much difference between both tools. In addition the researcher has ever read and learnt the thesis which have written by Muhammad Adieb *(Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite, (UIN Walisongo Semarang: 2014)* which explained about the comparacy between theodolite and istiwa'aini in determining the qibla direction by the result is only less than 2 degree the difference of measurement between Theodolite and Istiwa'ain . So, based on that research, it means Istiwa'aini is not only accurate to find out the qibla but also it has function as parameter for the measurement result of the research of this thesis which have been written by the researcher about *the Comparative Study of Mizwala and Istiwa'aini as Qibla Finder*. The result of the thesis is less than 1,2 degree for the difference between both tools. It means Mizwala and Istiwa'aini are accurate qibla finder even though they have several strengths and weaknesses.

Keywords : *Qibla finders, Mizwala and Istiwa'aini.*

CHAPTER 1

INTRODUCTION

A. Research Background

In the perspective of Islamic law, the scholars have demanded that one of the legitimacy of worship for Muslim (when performing salah) is facing the Qibla. The Qibla what they mean is Kaaba *(Baitullah).* [1] Kaaba is a building in the center of the most important mosque for Muslim, that is *Al-Masjid Al-Haram* located in Mecca. It looks like a cube, in Arabic it's called *Mukaáb*, then people call it Kaaba. It is the most sacred site in Islam. The direction to Kaaba is determined from every point of place on surface of the earth by measuring the astronomical formula and using *Qibla Finder* [2] . Therefore, the calculation of it is basically a calculation intended to know in which direction to Kaaba in Mecca can be seen from every location on the earth.[3]

Fiqh[4] and science are interrelated and supportive in determining the qibla. Jurisprudence is the foundation, while

[1] Ahmad Jaelani, *Hisab Rukyat Kiblat (Fiqh, Aplikasi Praktis, Fatwa dan Software).* Semarang : PT.Pustaka Risky Putra, 2012, p. 1.

[2] Classic or modern astronomical instrument to find out the qibla or qibla direction

[3] Slamet Hambali, *Ilmu Falak Arah Kiblat Setiap Saat,* Yogyakarta: Pustaka Ilmu, 2013, p. 4.

[4] The science of ascertaining the precise terms of the Shariah, or Islamic law.

science can be the instrument for *ijtihad*.[5] Trough science, we can find somebody's position and the qibla direction. Science in this case includes the theories and the methods for the measurement, then the theories include spherical trigonometry theories, methods, geodetic theory, and at cetera.[6]There are five main methods to measure it, those are :[7]

1. The method of determining qibla using compass.
2. The method of determining qibla using *an* istiwa' stick by taking the sun's shadow before and after *zawal*.[8]
3. The method of determining qibla using global rashdul qibla
4. The method of determining qibla using local rashdul qibla
5. The method of determining qibla using theodolite aids from the position of the sun at any time.

The way used to show where the qibla location was declared since Prophet Muhammad ﷺ and the companions

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[5] A physical or mental effort,expended in a particular activity. An Islamic legal term referring to independent reasoning or the thorough exertion of a jurist's mental faculty in finding a solution to a legal question.

[6] Ahmad Izzuddin, *Kajian Terhadap Metode-metode Penentuan Arah Kiblat dan Akurasinya,* Jakarta: 2012, p. 62.

[7] Muhammad Adieb , *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite,* (Undergraduate Thesis of UIN Walisongo Semarang) 2014 , p.3

[8] The time frame in which the sun is at the highest point or zenith or midday and the prayer is not allowed.

era. The developed theory was using celestial bodies as guidance. When Prophet Muhammad ﷺ was in Medina, he performed salah by facing south. Medina was located in north of Mecca caused the direction to Kaaba facing south. Prophet said that between east and west was the qibla. In development precisely in middle ages, the determination of qibla used the star Conopus (Najm Suhail) which mostly rises in the southern hemisphere and the direction of sunrise in summer solstice (Inqilab asy- Syaity).[9]

Historically, the method used to find out the qibla in Indonesia develops in accordance by the quality and the intellectual capacity of the Muslims. The advancement of it can be seen from the great changes in *Muhammad Arsyad al-Banjārī*[10] and *Kyai Ahmad Dahlan*[11] era and also the astronomical instruments they used, for example: *miqyas; stick Istiwa, Rubu 'Mujayyab, compass, theodolite*, and et cetera.

However, there are many problems faced by Muslims in Indonesia when they need to determine the qibla direction, one of them is the numerous methods and astronomical equipments used with complex calculations trough simple way up to fairly modern methods. People are truly confused to think and choose which tool is actually the

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[9] http://jayusmanfalak.blogspot.co.id/2013/02/permasalahan-arah-kiblat-antara_4415.html?m=2. It was accessed around in the middle of November

[10] A Syafi'i Jurisprudence scholars from Martapura, Borneo.

[11] Scholars, the founder of Muhammaddiyah Organization

best and the most accurate one. Some people even do not know how to do it properly.

Slamet Hambali and Hendro Setyatno are astronomers in Indonesia who have been successfully creating simple qibla finder. Those are *Istiwa'aini* by Slamet Hambali and *Mizwala* by Hendro Setyatno. Both tools are not difficult to utilize. Everyone can use them either people who already master the astronomical calculation or ordinary people who do not know yet about it as long as they want to learn how to use istiwa'aini and mizwala properly.

The principle of *Mizwala* by Hendro Setyatno is a modified approach of the sun clock or *sundial*[12], so that its function becomes better. The sun clock was very popular to determine the time, then after years later it also could be used to find out the qibla. *Mizwala* has three main components, those are :

1. Gnomon, to form the shadow.
2. Dial table, as a place where the shadow of gnomon falls.
3. Field level, located at the bottom of Mizwala, it's used to measure the flat.

Istiwa'aini by Slamet Hambali is a classic qibla finder. It has two istiwa' sticks, one of them is mounted at

[12] A horological device which tells the time of day when there is no sunlight

center of the circle and another one is in 0^0 position. Istiwa'aitni consists of two important components, those are :

1. The circular dial field. It is a circle-shaped instrument which is already designed including the scale. This field is as catcher of sun's shadow generated from the gnomon paired at center of circle of the dial plane and at the edge of the circle line.
2. Two shaping rods (gnomon) which serve to capture the shadow of the sun and adjust the two shadows so that a straight line can be drawn.

For the calculation, Istiwa'aini and Mizwala employ manual method by using calculator. They are more practical to use than any other astronomical instruments such as *teodholite, rubu 'mujayyab*, and so on. The working principle of them is using sunlight. Although they almost really look the same because of the similarities in term of shape they have but they are totally different. Therefore, the researcher was very interested in doing more research about Mizwala and Istiwaaini as qibla finder. That was why the researcher intended to conduct the studies then wrote it in an undergraduate thesis by the title: **"Comparative Study of Mizwala and Istiwa'aini as Qibla Finder".**

B. Statement of The Problem

Based on the background of study above, the researcher would identify the problems which are formulated in the questions bellow,

1 . How are the way and the method used to find out the qibla by using Mizwala and Istiwa'aini ?
2. How is the accuracy of Mizwala and Istiwa'aini in determining the qibla ?

C. Aim and Significance Research

Concluding the background described above, these research has some specific purposes. Those are :

1. To know the way and the method which are used to find out the qibla by using Mizwala and Istiwa'aini.
2. To know the accuracy of Mizwala and Istiwa'aini in determining the qibla.

In addition, this research also has significance mentioned bellow :

1. Give specific information about the usage of Mizwala and Istiwa'aini
2. As information data for the next research.

D. Preview of Literature

In this phase, the researcher would have searched some literature of sources from books, journals, articles and other previous researches. There were several previous studies which would be used as one of the research foundation to develop the clear framework from the formulation of problems which would be researched. Those previous studies are :

1. Undergraduate Thesis of Ade Mukhlas by the title *Analisis Penentuan Arah Qiblat Dengan Mizwala Qibla*

Finder Karya Hendro Setyatno (2012). This thesis explains the procedure of using *Mizwala* as Qibla Finder specifically..

2. Undergraduate Thesis of Muhammad Adieb by the title *Studi Komparasi Penentuan Arah Kiblat Istiwaaini Karya Slamet Hambali Dengan Teodholite*. This thesis explains the usage of *istiwa'aini* and *theodolite* in determining the qibla direction and the comparative analysis of both instruments.
3. The Individual Research Report of Slamet Hambali by the title, *Menguji Keakurtan Hasil Pengukuran Arah Kiblat Menggunakan Istiwa'aini Karya Slamet Hambali.* This report explain about the how to use Istiwa'aini in right way to determine the qibla direction and how the accuracy of it.
4. The Thesis of Lutfi Nur Fadhilah by the title, *Mizwala dan Istiwa'aini Instrumen Hisab Rukyat Klasik.* This thesis explain about the definition and how to use Mizwala and Istiwa'aini.There are more previous research can be used as research foundation but the closest one for the data is the research mentioned above.

E. Research Methodology

This thesis uses several methods in writing to obtain the data as way of scientific approach. The methods used are :

1. Research Category and Approach

This is a kind of quantitative research which use field research. In this study, the data is obtained from some sources and direct measurement at field. The researcher conducted qualitative approach with descriptive approach. It is expected to facilitate the conclusion of various generalizations obtained from the data which has been already collected, then it will be able to describe *Istiwaaini* and *Mizwala* completely.

2. The Source of Data Type

Considering that thus research is Field research, so it has two types of data, those are primary source and secondary source. The primary source is the result of the astronomical calculations and measurements to determine the qibla direction using Mizwala and Istiwa'aini. Then, the data generated from those measurements are used as primary data.

The Secondary data is obtained from books, articles, and journals which explain about qibla direction. Secondary data is also obtained by conducting interviews to some parties related to this research.

3. The Method of Data Collection

To obtain the necessary data for the research, the data collection techniques will be used are :

a. *Interview,* it is used to collect the information for the research. The informen are Slamet Hambali as the creator of *Istiwaaini* and Hendro Setyatno as the creator of *Mizwala*. The type of interview used are structured interview, it is an interview which questions are prepared first before being asked to informen.

b. *Observtion*, this is a method to find out the data by observing the instruments used as the objects of research. The material and knowledge of the observation results would be be collected, processed and studied. In this case, the researcher has used *Mizwala* and *Istiwaini* when conducting field research. The research would be conducted at Masjid Al-Ikhlas BPI Ngaliyan, Semarang, Central Java.

c. *Documentation*, this method is documenting the data obtained from various sources either from research-related books, field research, or interviews.

4. Method of Data Analyzing

This research would use several methods of data analysis, those are :

1. To analyze the data obtained, the paradigm used is a qualitative research method using descriptive approach.
2. Comparative, compare between *Mizwala* and *Istiwa'aini* as qibla finder.

F. Research Outline

This thesis consist of five chapters, those are :

CHAPTER 1 : INTRODUCTION

This chapter explains the background of the research, statement of the problems, the purpose and the significance of this research, previewing the literature, and the research method or technique which is used for the thesis.

CHAPTER 11 : THEORITICAL DESCRIPTION

This chapter explains about the general definition and views of qibla, the legal basis to face the qibla while praying (doing salah), the data which is needed the methods and the instruments used.

CHAPTER 111 : THE METHOD USED TO FIND OUT THE QIBLA BY USING ISTIWA'AINI AND MIZWALA

This chapter explains about Mizwala and Istiwa'aini, the biography of the creator, the general description of their systematic , and the description of the method used.

CHAPTER 1V : THE COMPARACY OF MIZWALA AND ISTIWA'AINI AS QIBLA FINDER

This chapter explains about the analysis of mizwala and istiwa'aini, the comparison between each other, and the accuracy of both tools.

CHAPTER V : CLOSING

This chapter consist of the conclusion of the thesis.

CHAPTER II

THEORITICAL DESCRIPTION

A. The Definition of Qibla

The word falak means the orbit of celestial bodies, so that falak science *(Ilmu Falak)* is the science which studies the path of heavenly bodies, especially the earth, the moon and the sun in their orbits respectively. The synonymous with it is astronomy but they are a little bit different. Falak science is the term used by Muslims to learn about heavenly bodies as the importance of worship such as the direction of qibla, the Islamic prayer times, the beginning of the month and eclipse. While astronomy is the science which studies celestial bodies in general. Astronomy is the scientific study of the stars, the moon, the planets, the galaxies, the dark matter and others which can be observed by scientific methods: by using mathematics, science, computers, telescopes (optical and radio), or spacecraft. There is no dichotomy ology between astronomy and falak science.[1]

According to falak science (sometimes people call it Islamic Astronomy), qibla is the nearest direction towards Kaaba while performing *Salah*.[2] Etymologically, the word qibla is from Arabic قبلة which is a form of *masdar*[3] from

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[1]ww.astronomie-dz.org/index.php/en/les-outils/les-instruments-2/172-astronomy-astrology-and-falak-science. It was accessed aroubd December

[2] Islamic worship or prayers which are performed by Muslims

[3]noun of a *Fiil* or verb that is not related to a certain time

the verb قبليقبل which means facing. Meanwhile, in terms of terminology, the word qibla has several definitions.[4]

Kaaba is a building at the center of the most important mosque for Muslims, that is Al-Masjid Al-Haram located in Mecca. It looks like a cube, in Arabic it's called Mukaáb, then people call it Kaaba, it's also spelled Ka'ba. It is the most sacred site in Islam. The direction towards Kaaba is determined from every point of place on surface of the earth by calculating the astronomical formula and using qibla finder. Therefore, the calculation of it is basically a calculation intended to know in which direction of Kaaba in Mecca can be seen from any location on the surface of the earth.

There are some specific definitions of Qibla according to Astronomers, those are:

1. Harun Nasution defines qibla as the direction to face when Muslims are doing shalah.
2. Mochtar Effendy interprets qibla as the direction to face when praying, the direction of the Kaaba in Mecca.
3. The Ministry of Religion of the Republic of Indonesia defines qibla as a certain direction for Muslims to direct their faces when praying.
4. Slamet Hambali provides a definition of Qibla as the direction which Muslim must face when performing shalah, namely the direction to the

[4] Wikipedia Indonesia

Kaaba *(Baitullah)* through the closest route. It is an obligation for every Muslim to face the direction when praying, wherever they are.

Thus simply what is meant by Qibla, the direction with the closest distance to the Kaaba in Mecca, and every Muslim is truly obliged to face towards it when praying. There are also other definitions of Qibla according to Quran. Those are :

1. Al-Baqarah : 142

"The fools among the people will say : "What has turned them from their Qiblah [prayer direction (towards Jerusalem)] on which they were"? Say: "The East and the West belong only to Allah. He guides whom He wills to the Path (that leads to Allah). (Al-Baqarah:142).

2. Al- Baqarah : 143

"Thus We have made you a medium (just, balanced, good, superior, virtuous) nation, that you be witnesses over mankind and the Messenger be a witness over you. And We made the Qiblah (prayer direction towards Kabaa) on which you were, only to (distinguish and) know those who depended on (followed) the Messenger from those who would turn on their heels. And it is surely hard except for those whom Allah caused to attain guidance (it is not hard for them); and Allah is not going to waste your faith. Truly Allah is Affectionate, the Most Merciful towards mankind. (Al-Baqarah: 143)"[5]

3. Al-Baqarah : 144

[5] *Ibid*

"Verily, We have seen the turning of your face towards the heaven (waiting for the Divine Decree). Surely, We shall turn you to a Qibla (prayer direction) that shall please you; so turn your face in the direction of the Inviolable Sanctuary (Al-Masjid Al-Harâm in Makka), and wherever you may be, turn your faces towards it. Those to whom the Book was given know this to be the truth from their Lord. And Allah is not Unaware of what they do. (Al-Baqarah:144)"

4. Al- Baqarah : 145

"And even if you were to bring to those who have been given the Book every sign, they would not follow your Qiblah (prayer direction), nor would you follow their Qiblah; nor will they follow each other's Qiblah. If, after all the knowledge you have been given, you follow their desires, then you would surely become amongst the wrong-doers (unjust, evil-doers). (Al-Baqarah:145)."[6]

5. Yunus : 87

"We revealed to Moses and his brother: "Build for your people houses to dwell in Egypt, and make your houses a kiblah (places of worship) and keep up the prayer and give glad tidings to the believers. (Yunus:87)."

[6] *Ibid*

B. The Legal Basis of Facing Qibla

The scholars have made an agreement or consensus (*ijma*)[7] which determines the Kaaba as the qibla for every Muslimin carrying out salah, based on the *Qur'an*[8] and the *hadiths*[9]of Prophet Muhammad ﷺ,The legal basis of finding qibla are :

1. The legal basis from Qur'an (Al-Qur'an)

   There are many verses of the Qur'an which explain about faccing the Qibla, those are :

   a. Al-Baqarah : 144

[7] the agreement of the scholars in establishing the legal law in religion based on the Qur'an and Hadith in a case which is occurred

[8] The holy book of Islam, the central religious text of Islam which is a revelation from God

[9]The narration of an event from the life of Prophet Muhammad ﷺ

"Verily, We have seen the turning of your face towards the heaven (waiting for the Divine Decree). Surely, We shall turn you to a Qiblah (prayer direction) that shall please you; so turn your face in the direction of the Inviolable Sanctuary (Al-Masjid Al-Harâm in Makka), and wherever you may be, turn your faces towards it. Those to whom the Book was given know this to be the truth from their Lord. And Allah is not Unaware of what they do." (QS.Al-Baqarah:144).

b. Al-Baqarah : 150

"And from wherever you set out, turn your face in the direction of the Sacred Mosque (Al-Masjid-ul-Harām), and (O Muslims), wherever you are, turn your faces in its direction, so that people should have no argument against you, except for those among them who are unjust,- do not fear them, but fear Me-, and so that I should perfect My blessings upon you, and that you

may take the right path." (QS. Al-Baqarah :150).

c. Al-Baqarah:149

"So from wherever you depart, turn your face towards Al-Masjid-Al-Harâm, that is indeed the truth from your Lord. And Allah is not Unaware of what you do." (QS.Al-Baqarah:149)

The verses of the Qur'an above instruct Muslims to face Ka'bah accurately when performing prayers.

2. Legal Basis from Hadith

In addition to the legal basis for facing the Qibla contained in the Qur'an as the first source of law, there are many hadiths related to the attitudes, words, and actions of the Prophet Muhammad ﷺ as an explanation and application of the command to face the Qibla in the Qur'an. Among the hadiths related to explanations and the basis for facing the Qibla is the hadith narrated by

Imam Muslim from the companion of Thabit bin Anas. He said :

حدثنا ابوبكرابن شيبة حدثنا عفان حدثنا حماد بن سلمة عن ثابت عن أنس أن رسول الله صلى الله عليه وسلم كان "يصلي نحو بيت المقدس فنزلت قد نرى تقلب وجهك فى السماء فلنولينك قبلة ترضها فول وجهك شطر المسجد الحرام" فمر رجل من بنى سلمة وهم ركوع فى صلاة الفجر وقد صلوا ركعة فنادى ألا ان القبلة قد حولت فمالوا كماهم نحو القبلة. (رواه مسلم)

"Abu Bakr bin Abi Saibah, narrated, 'Affan narrated, Hammad bin Salamah narrated, from Thabit from Anas:Indeed the Messenger of Allah (ProphetMuhammad) wasprąying facing the Baitul Maqdis, then the verse came down: "Indeed I see your face half looking up at the sky, so we really turn your face to the Qibla you wish. Turn your face towards Masjidil Haram." Then a person from Banu Salamah was traveling and met a group of friends bowing down at the dawn prayer. Then he said, "Indeed, the Qiblah has changed". Then they turned like the Prophet's group, namely towards the Qibla "(HR. Muslim)".

There are also other hadiths narrated by:

a. Imam Bukhari from a friend of Abu Hurairah ra, Prophet Muhammadﷺ :

استقبل القبلة وكبر (رواه البخاري)

”Face towards the Qibla then do takbir(HR.Muslim).”

b. Imam Baihaqi, Prophet Mohammad SAW said :

مابينالمشرقوالمغربقبلةإذاتوجهنحوالبيت

(رواهالبيهقي)

“Between east and west is Qibla if someone faces it towards the Baitullah. (HR. Baihaqi)”

Although the scholars have known about kaaba as the qibla of Muslims in carrying out their worship obligation, there are different opinions of them regarding the technical aspects of facing the qibla for the areas which are too far from kabaa.

There are two versions of opinion among scholars. The first opinion states that wherever Muslims are, both near and far from the Kaaba, they must face the physical form of it (ain Kaaba). This opinion is supported by Imam Shafi'i and Imam Ahmad ibn Hambal. While the second opinion recommends Muslims to face the direction of the Kaaba only (jihah al-ka'bah). It is supported by Imam Abu Hanifah and Malik Ibn Anas. The meeting point of the two opinions contextually, for Muslims who are in territorial areas able to see the physical form of the Kaaba, so the way to face it is by facing the physical form (ain Kaaba), while those who are far away and can not see the physical form of the Kaaba, then it is permissible to not stand facing al-ka'bah but at least by strong suspicion.[10]

C. The calculation of Qibla Direction

We can see as well the development method todetermine the qibla from the astronomical instruments used to measure and the computating system used, both regarding coordinate data and the measurement system which is greatly assisted by the presence of calculation aids and increasingly sophisticated coordinate data researcher device such as GPS (Global Positioning System).[11]

In Islamic Astronomy, there are many methods used to find out the exact direction of qibla, including the calculation which is made with Spherical Trigonometry. In order to get accurate counting result, we need calculator, a 360-degree bow and compass but there are two main method which can be used, those are :[12]

1. Azimuth of Mecca (Qibla Azimuth)

   Azimuth of Mecca or Qibla azimuth means the arc of the horizon circle or the horizon calculated from

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[10]https://www.google.com/amp/s/www.kompasiana.com/amp/sancay/sejarah-menghadap-kiblat_550f0a07813311c52cbc671b. it was accessed on around October

[11] Ahmad Izzudin, *Ilmu Falak Praktis (metode hisab-Rukyah praktis dan penyelesaian permasalahannya) p.29*

[12]Thoyfur, Muhammad. Journal of Islamic Astronomy : *Digitalization of Rashdul Qbla by Qibla Diagram* .Pekalongan:2021.p. 77

north point to east (clockwise rotation) to Qibla point. North point is 0°, east point is 90°, south point is180° and west point is 270°. To find out the Qibla azimuth, some data are needed.[13] Those are :

a. Latitude of the location which we want to measure for the qibla direction. Latitude is a measurement on a globe or map of location north or south of the Equator. Technically, there are different kinds of latitude, those are geocentric, astronomical, and geographic (or geodetic) but there are only minor differences between them. In most common references, geocentric latitude is implied. In this case latitude what we mean is the distance from the area we want to measure to the equator measured along the longitude. The equator is 0° and the earth's pole is 90° . South of the equator is called south latitude (SL) with a negative sign (-) and north of the equator is called North latitude (NL) is given a positive sign.[14]

b. Longitude of the location where we want to measure for the Qibla direction. Longitude is a measurement of location east or west of the prime meridian at Greenwich, the specially designated imaginary north-south line that passes through both

[13] *Ibid*.78
[14] *Ibid*.80

geographic poles and Greenwich, London.[15] In this case the longitude location which we mean is the distance from the preferred place of longitude through the city of Greenwich near London. Located west of the city of Greenwich up to 180° is called West Longitude (WL) and east of the city of Greenwich up to 180° East Longitude (EL).[16]

c. The latitude and longitude of Mecca (Kaaba). The latitude of Mecca is 21° 25´ 21.17´´ (NL) and Mecca Longitude is 39° 49´ 34.56´´(EL). According to Ahmad Izzuddin (2010: 32), the data for the coordinates of Kaaba is very diverse where the coordinates of it have also been carried out by the Geodesy KK Team who took the initiative to take direct measurements with the WGS 84 system coordinated by Joenil Kahar who used the Magellan GPS-3000 navigation GPS receiver when performing the pilgrimage. Then re-measured by Dr. Hasanuddin Z.A. using Garmin E MAP with data latitude 21° 25´ 21.5" N and longitude 39° 49´ 34.5´´ East.[17]

We can see the different coordinates according to the data mentioned above but the difference is due to the position of the satellite when using the same GPS.

[15] https://www.britannica.com/science/latitude it was accessed on December,3, 2021

[16] *Ibid*.80

[17] *Ibid*.80

The difference is only for seconds, so the difference for the calculation results does not reach degrees.[18]There are several ways to findlatitude and longitude of a location on Earth, some of which require many more resources than others. The ways are :

a. *Understand Latitude and Longitude*

1) Understand Latitude, it measures how far a point is north or south of the equator. Since the earth is round, distance from the equator is measured in angular degrees with the equator being 0 degrees and the northernmost point -- the North Pole -- being at 90 degrees. The southernmost point -- the South Pole -- is also at 90 degrees.[19]Latitude is measured in degrees north when in the northern hemisphere and degrees south when in the southern hemisphere.

2) Understand Longitude, it measures how far a point is east or west of the prime meridian arbitrarily set as Greenwich, England. Since the Earth is round, distance from the prime

[18] Ahmad Izzuddin, *Ilmu Falak Praktis; Metode Hisab-Rukyat Praktis dan Solusi Permasalahnnya*, *op.cit*; 31.

[19] http://faculty.chemeketa.edu/afrank1/topo_maps/lat-long.htm. It was accessed on December, 5, 2021

meridian is measured in angular degrees with the prime meridian being at 0 degrees longitude. As you move east or west, the longitude measures up to 180 degrees of the prime meridian. 180 degrees longitude is known as the international dateline.[4]

3) Know the accuracy of your readings**.** degrees are a large unit of measurement so to get an accurate location, longitude and latitude are divided to the decimal point referred to as decimal degrees. For example, you may see latitude as 35.789 degrees North. Global Position Systems (GPS) often show decimal degrees but printed maps do not.

4) Understand how they appear on a map**.**always assume that the top of the map is north. The numbers on the right and left side of a map refer to the latitude. The numbers on the top and bottom of the map are the longitude. Please remember how to convert time in order understand a map using decimal degrees as degrees, minutes, and seconds.15 seconds = one quarter of a minute = 0.25 minutes, 30

seconds = half a minute = 0.5 minutes45 seconds = three quarters of a minute = 0.75 minutes

b. *Looking into Books or Map*

This method is the easiest way to find the geographical coordinates (latitude and longitude) of a place, by looking or searching in the list available in existing books. Although it seems easy, there are a few things which need to be considered in using this method, those are

1. Obtain a USGS map, A U.S. Geological Survey map is standardized map created by the National Cooperative Geologic Mapping Program under the U.S. Department of the Interior.
2. Look for the latitude and longitude, these measurements are often in the corner of the map. Beneath the title you may also notice how far the map covers.
3. Find the location, depending on the scale of your map, it may take some time to find your location. Note the city, town, or specific point on the map that denotes your current

position. Once found, mark your location.

4. Use a map ruler to check the degrees, measure from your location outwards from the map to the straightest numbered line of latitude or longitude. The map will be divided into both vertical and horizontal lines to represent the measurements of longitude and latitude. The 4 corners of your map will display the coordinates of both the longitude and latitude fully written out. Only the final two digits will be shown for all other points in between.
5. Write your coordinates down, the standard procedure is to write the latitude first, followed by the longitude, with both written to as many decimals as possible. The more decimals you are able to achieve, the more accurate and precise the location.

c. *Use a Protractor*

a. Make sure that it is noon, determining the latitude with the sun can only be done when it is at its highest point

b. Use a compass to establish north and south, you may only set up your measurements knowing north and south. Mark north and south with a line running along the ground. Set up a quadrant with its aiming beam parallel to this line

c. Create a quadrant, or cross, using two pieces of wood. The aiming beam -- or hands of the cross -- should be centered on the support beam-- or body of the cross -- so that it can pivot up and down

d. Align the sighting nails of the quadrant with the sun. Once noon, line up the nails on the aiming beam with the sun

e. Use the protractor to measure the small angle between the beam and the plumb line. Once the beam is aimed correctly, use the protractor to measure from the vertical plumb line to the portion of the aiming beam closest to it. Keep the horizon at 90 degrees as you make your measurements.

f. Understand that the time of year plays into the accuracy of your reading.

d. Use Theodolite

This is a more precise way to find latitude and longitude. Theodolite is a measuring instrument as binoculars equipped with a lens, numbers that indicate direction (azimuth) and altitude in degrees and a spirit level.

e. Using a Istiwak Stick.

This method is quite easy to practice and accurate because this method uses nature as a medium to determine geographic coordinates.

f. Using GPS (Global Positioning System)

GPS is an electronic device which works and combines signals from satellites to determine the position of places on Earth. How to operate the GPS is as follows:[20]

1. Place GPS in an open location. Always use the “Chart Table Mount” to ensure that GPS antenna is facing upwards.
2. In the upper right corner will appear the words "searching", a few moments later it will change to "Get Data", then finally to "Locked."
3. After the word "Locked" appears, press the "POS" button and the screen

[20] *Ibid.*

will display the latitude and longitude of the respective place.

We can use the simple formula to find qibla, that is :[21]

Cotan B = tan φk . cos φx : sin C – sin φx : tan C36

B is the Qibla direction. If the result of calculation B is positive, then the Qibla direction is calculated from the north point. Meanwhile, if the result of the calculation of B is negative, then the Qibla directions calculated from the south.

Description:

a. Φk is latitude of the Kaaba which is 21° 25' 21.04”37
b. φx is the latitude where the Qibla direction will be measured.
c. Λk is the Longitude of the Kaaba which is 39° 49' 34.33”38
d. C is the longitude distance, which is the longitude distance between the Kaaba and the longitude of the place to be measured by the direction of the Qibla.

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[21] Adieb, Muhammad , Undergraduate thesis; *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite,* UIN Walisongo Semarang: 2014. P,56

How to calculate C based on the distance from the Kaaba to the area where the Qibla direction is calculated, as follows:

a. If BTx > BTk, then C = BTx – BTk (Qibla = West)
b. If BTx < BTk, then C = BTk – BTx (Qibla = East)
c. If BBx < BB 140° 10' 25.06", then C = BBx + BTk (Qibla = East)
d. If BBx > BB 140° 10' 25.06", then C = 360° - BBx – BTk (Qibla = West)

While the formula for calculating the Qibla azimuth is:

a. If B = UT (+), Qibla Azimuth = B (fixed)
b. If B = UB (+), Qibla Azimuth = 360° - B
c. If B = ST (-), Qibla Azimuth = 180° - B (B is positive) If B = SB (-), Qibla Azimuth = 180° + B (B is positive)

2. Rashdul Qibla

Rashdul-qibla is a provision where the shadow of an object exposed to sunlight points towards the Qibla.[22] It is a method of determining the direction of qibla which is known to be economical, practical and

[22]Ahmad Izzuddin, *Ilmu Falak Praktis; Metode Hisab-Rukyat Praktis dan Solusi Permasalahnnya, op.cit.*, : 45.

accurate. In practice, Raṣdu Qiblah is restricted due to the presence of the sunray and the limited time. As the result, Rashdul Qiblah formula with azimuth angle is developed as a solution which can be utilized four times or more in a day.[23]

Basically the method used to measure the Qibla direction is using the sun's shadow. Shadow of the object exposed to sunlight will form a shadow pointing toward the Qibla.[24]it comes on 28/27 May and 15/16 July every year.[25]

If Mecca time is converted to West Indonesian Time (WIB) then it must be added by 4 hours so it is equal to 16.18 WIB and 16.27 WIB. Therefore, every May 28 or

May 27 (for a leap year) at 16.18 WIB the direction of qibla can be checked by relying on the shadow of the sun which is above the Kaaba. for July 16 or July 15 (for leap years) it is also possible to check the Qibla direction with the rashdul qibla method.[26]

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[23] http://ejournal.iain-tulungagung.ac.id/index.php/ ahkam/article/view/ It was accessed on November 12,2021

[24], Muhammad Adieb, Undergraduate thesis: *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite,* UIN Walisongo Semarang : 2014, *Op cit.*

[25] *Ibid. 27*

[26]Muhammadiyah Reckoning guide, *Pedoman Hisab Muhammadiyah*, Majlis Tarjih dan Tajdid Pimpinan Pusat Muhammadiyah (Majlis Tarjih dan Tajdid PP. Muhammadiyah. Yogyakarta: 2009 II,p. 34.

how to check the qibla direction during this phenomena is as follows:[27]

1. Adjust the time which is used by BMKG atomic time.
2. Use a tool which can be used for making perpendicular to flat ground.
3. Wait for 5 minutes before the phenomenon occurs and 5 minutes after the phenomenon is completed. By paying attention to the shadow of the pendulum.
4. Draw a line from the end of the shadow to the position of the tool, that is the Qiblah which is shifted position when the sun is above the Kaaba

D. Qibla measuring Instruments

There are many Qibla finder which we can use to find Qibla direction. The method which is used to find the Qibla in Indonesia has developed in accordance with the development of knowledge possessed by the Islamic community itself. There are five kinds of methods for measuring the Qibla direction in Indonesia, namely:

1. The method of measuring the Qibla direction using compass

[27]https://dnktv.uinjkt.ac.id/index.php/catat-baik-baik-cara-cek-arah-kiblat-saat-rashdul-qiblah/. It was accessed on November, 12, 2021

2. The method of measuring the Qibla direction using an istiwak stick by taking the shadow of the Sun before the zawal and before the zawal.
3. Qibla direction measurement method using global rashd al-qibla.
4. Qibla direction measurement method using local rashd al-qibla.
5. The method of measuring the Qibla direction using a theodolite tool from the position of the Sun at any time.

Those Qibla direction measurement methods which are developed in Indonesia can be classified into two, those are Qibla Direction Measurement Method with Classical Tools and Qibla Direction Measurement Method with Modern Tools.

CHAPTER III

THE METHOD USED TO FIND OUT THE QIBLA BY USING MIZWALA AND ISTIWA'INI

A. Biography of Hendro Setyatno

Hendro Setyatno is an astronomer, was born in Semarang on October 1, 1973. He is the alumni Tebuireng Islamic Boarding School. During his time as a student, he did not like astronomy because he thought it was confusing and hard to learn, but then he continued his study at Department of Astronomy at Bandung Institute of Technology. Now he becomes a successful astronomer who has create Mizwala Qibla Finder.

After graduated from high school in Tebuireng, he did not aspire to pursue astronomy, but after attending to university, finally he fall in love with it because he thought astronomy was unique and always amazed him because of the many secrets hidden by the universe.

When he was still a high school student, he thought that astronomy was identical to the "western" world and it is not closely related to Falak Science (Islamic Astronomy) because Falak Science is only discussed about religion. He just found out that astronomy is closely related to religious science when he started to pursue astronomy at ITB.

The wider the knowledge he gets about astronomy, the more challenging it is to continue learning it. But in his little heart a question arose, "Does people know, especially the younger generation, know about all the beauties and secrets of this science?". This question inspired him to start his small dream, which is to introduce the universe to the public.

Armed with experience guiding the community at the Bosscha Observatory since 1998, Hendro began to realize his small dream by bringing a telescope to various places such as schools and also several mosques. It made his name known everywhere.[1]

In 2008, After working hard finally his dream came true. He created a car observatory. It is equipped with refractor 102 XLT tracking binoculars, 80 mm Reflector, and 70 mm APO, a 32-inch TV complete with sound equipment and a computer connected to the 3G network, and completed with other accessories. By this creature, his firmly believes that his dream to introduce astronomy to the public especially children who live in hard to reach areas will be realized.

Hendro also got a muri record in 2009 as the operator of the first observatory car in Indonesia. Hendro also got his second MURI record in 2016 because his work is in the form of the largest eclipse glasses in Indonesia at Terentang Beach, Central Bangka Regency, Bangka Belitung Province.

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[1]https://www.kompasiana.com/alam8322/5bbe36f2aeebe1354d3e0a97/hendro-setyanto-tokoh-inspiratif-yang-sukses-menggabungkan-antara-sains-dan-agama

Hendro has already obtained two muri records, but his strong determination to continue to innovate makes him not easily satisfied. Finally, in 2012 the idea was bold to create a forum to provide education for the wider community, namely an observatory with the concept of edutourism. Imah Noong, that's the name of the observatory which he has initiated.

Imah Noong is a simple observatory that can be a bridge for anyone who wants to learn about astronomy. Imah Noong itself comes from the Sundanese language, imah means house and noong means peek so that it means a house to "peek" at celestial objects.[2] Then the most important one is Hendro Setyatno has created such a supar amazing astronomical instrument called Mizwala Qibla Finder. It is really popular used by people specially for the students who learn astronomy or Falak science.

B. Biography of Slamet Hambali

Slamet Hambali is a national caliber figure. He was born on August 5, 1954 in a small village called Bajangan, Beringin District, Semarang Regency, Central Java. Since childhood he was already familiar with astronomy from his father, KH. Hambali. Slamet Hambali is the second of five children. Slamet Hambali's busy schedule in several state institutions where he works is the reason for living in Semarang, precisely in the residential area of Pasadena Krapyak, West Semarang with Hj. Isti'anah the wife he

[2] *Ibid*

married in 1984 and his two daughters Rusda Kamalia and Jamilia Husna.[3]

His Education started at Sekolah Rakyat ambirejo , but he did not finish it. Then he continued to return to SR Rembes and finished in 1966. Furthermore, Slamet Hambali began to enter a Islamic boarding school in Bancaan area which was hold by KH. Ishom then he continued his education at MTs NU Salatiga. After graduating from MTs in 1969, he continued to study at Madrasah Aliyah in the same place and graduated in 1972.

In addition, studied at Islamic boarding school of KH. Ishom, Slamet Hambali also studied with KH. Zubair Umar al-Jailani. Under the private guidance of Kyai Zubair, he studied astronomy by studying a book of astronomy entitled Al-Khulashah Al-Wafiyah. Kyai Zubair's upbringing made Slamet Hambali the most skilled student in astronomy. So when he studied at grade 9 in 1975, he started teaching astronomy to his classmates. The activity of teaching astronomy continued in the following year, he taught astronomy to his juniors.

Slamet Hambali completed the Undergraduate Program at IAIN Walisongo in 1979. After that, he did not immediately continue with his master's degree, because he was busy of teaching astronomy at several universities in Central Java. In addition to teach astronomy at IAIN Walisongo, he also taught astronomy at Sultan Agung

[3] Barokatullaili, Analisis Metode Pengukuran Arah Kiblat Slamet Hambali (Skripsi Fakultas Syariah IAIN Walisongo) Semarang, 2013, p.57

University (UNISSULA) Semarang, the Nahdlatul 'Ulama Islamic Institute (INISNU) Jepara, Wali Sembilan Islamic College (STAI Wali Sembilan) in Semarang, and STAIN Surakarta. (It is IAIN Surakarta now). Finally, due to the consideration that the distance is too far and the schedule is very tight, he decided to reduce his teaching activities at some of these universities.[4]

Slamet Hambali often fills seminars, both national and international seminars, which are conducted in Semarang and outside of Semarang. In addition to attend the seminars, Slamet Hambali often provides training on measuring the Qibla direction and the beginning of the month for his students. While devoting himself to IAIN Walisongo by teaching astronomy and celestial science, he continued his postgraduate education at IAIN Walisongo Semarang. On January 27, 2011, he completed his Masters in Islamic. In his busy life, Slamet Hambali has written several books and created an astronomical instruments, those are :[5]

1. *Ilmu Falak 1 (Penentuan Awal Waktu Salat dan Arah Kiblat Seluruh Dunia)*. This book contains an explanation of the basics of astronomy, the derivative of the spherical triangle formula until it is applied in the initial

[4] *Ibid. p, 59-60*

[5] Muhammad Adieb; *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite, (Undergraduate thesis).* UIN Walisongo Semarang : 2014

measurement of prayer times and in calculating the Qibla direction.

2. *Almanak Sepanjang Masa Sejarah Sistem Penanggalan Masehi Hijriyah, dan Jawa*. This book was published by the Postgraduate Publisher of IAIN Walisongo Semarang.
3. *Pengantar Ilmu Falak Menyimak Proses Pembentukan Alam Semesta*. This book discusses more about astronomy from an astronomical point of view. Starting from the process of the occurrence of the universe, Earth and everything in it, as well as the history of astronomy according to existing expert figures. At the end of the book, it is explained about the celestial coordinates which is an initial provision in understanding astronomy in observing natural phenomena that occur.
4. *Ilmu Falak (Arah Kiblat Setiap Saat.* This book describes the most phenomenal method of measuring the Qibla direction of Slamet Hambali
5. *Istiwa'aini the Qibla Finder.* It is a classic astronomical instrument to find out the qibla.

C. Find Out The Qibla by Using Mizwala

1. The definition of Mizwala

The word Mizwala is from Arabic which means sundial or the sun clock but it has been modified. The principle of it is a sundial that has undergone increasingly complex modifications. In the past, sundials were popular for determining time only, but nowdays it can be activated to determine the Qibla direction. Mizwala is created by Hendro Setyanto MSi, an ITB astronomy alumnus, It has three main components, a gnomon (special stick), a dial table, and a level field.

Image 3.1, Mizwala Qibla Finder

2. The components of Mizwala

   Mizwala has several components, those are :

   a. Gnomons (miqyas), are the shadow-formers placed in the middle of the dial circle. Their heigh is 10 cm with sharp tip so that the shadow does not widen and only forms a point. The length of the gnomon is adjusted to the radius of the circle of the rotating dial so that the resulting shadow does not exceed the plane.

Image 3.2 Gnomons (miqyas)

b. The swivel dial area, its functions is as sun’s shadow receiver which is produced by the gnomon. It can be rotated up to 360°. The function of the rotation of the dial is to make the Qibla direction measurement possible in a short time (less than 5 minutes). This plane has a smaller area than the level plane with a radius of 15 cm. In this plane there is a curve consisting of concentric circles and an azimuth scale from 0°-360° with an interval of 15°. This swivel dial area distinguishes the Mizwala Qibla finder from the general stick.

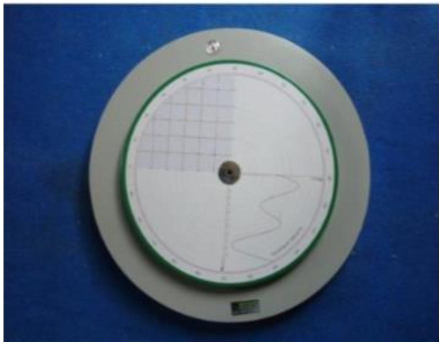


Image 3.3. The swivel dial area

c. The Level field, which is the most basic part that serves as the base of all components. This level plane also functions as a level regulator with 3 feet contained in this level plane, besides that the level plane is equipped with a small compass as a guide for directions. After all these components exist, then the components are assembled into one as in the picture below.[6]

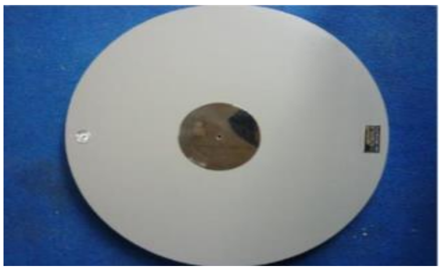


Image 3.4, The Level field

[6]Siti Tatmainul Qulub, *"Ilmu Falak (Dari sejarah ke teori dan aplikasi)"* PT Rajagrafindo persada. 2017 ,p.162

3. Find out the qibla by using Mizwala

There are several steps we need to do if we want to find out the qibla or the qibla direction by using mizwala, those steps are :

a. Find out the true north direction

To determine the true north direction using mizwala, it requires some datas, those are :

- Latitude of the location (ϕ^x)
- Longitude of the location (λ^x)
- Longitude (λ^d)
- Measurement Time (WD)
- Declination at the time of measurement (δ)
- Equation of time (e)

b. Find out the azimuth of the sun's shadow (mizwah)

After the data is obtained, what we need to do for the next is looking for the azimuth of the sun's shadow (mizwah). To calculate the value of the mizwahada, here are several steps you need to do

1. Find the angle of solar time with the formula:

$$\boxed{\textbf{t= WD+e-}(\lambda^{d}\textbf{-}\lambda^{x})\textbf{/15-12=.....x15}}$$

If the measurement is in the morning, the result is negative, if the measurement is in the afternoon, the result is positive.

2. Looking for the direction of the sun

Looking for the direction of the sun with the same formula as finding the direction of the

Qibla, but it is only the latitude of the Kaaba is replaced by the sun's declination and the difference in longitude is replaced by the angle of solar time, the angle of time used in finding the direction of the sun must be positive. Here is the formula :

$$\textbf{Cotan A} = \tan \delta \times \cos \phi^{x} / \sin t - \sin \phi^{x} / \tan t$$

If the declination of the sun is positive (+) then the value of the direction of the sun is also positive (+), as well as if the declination is negative (-). Therefore, the positive or negative value of the sun's direction follows the positive or negative of the sun's declination.

3. Calculate the azimuth of the sun

   Calculate it by using the following rules:

   - Morning = positive declination = azimuth = sun direction
   - Morning = negative declination = azimuth = 180+sun direction (-)
   - Afternoon=negative declination=azimuth=180-sun direction (-)
   - Afternoon=positive declination=azimuth=360-sun direction

4. Calculates the mizwah

   Calculates it which is the azimuth of the sun's shadow. Because the mizwah is the azimuth of the shadow, the value of the mizwah can be determined by drawing the opposite point of the sun's azimuth. So to calculate the mizwah the following rules needed:

Azimuth Matahari	*Mizwalah*
< 180° (kurang dari 180°)	Azimuth matahari + 180°
> 180° (lebih dari 180°)	Azimuth matahari - 180°

If the mizwah has been found, then the dial is rotated until the shadow of the gnomon falls on the mizwah. Then watch “0” on the dial area properly because it is automatically representing the true north. This is the example of the calculation :

The location : Masjid Al-Iklas BPI Ngaliyan, Semarang.

- Latitude (ϕ^x) : 6°59'35”
- Longitude of place (λ^x) : 110°21'12"
- Longitude (λ^d : 105° (Wib)
- Measurement Time (WD) : 14.00
- Declination At the time of measurement (δ) : 23°56'17”
- Equation of time (e) : 0m 3d

Finding the sun's time angle

t= WD+e-(λ^d-λ^x)/15-12=…..x15

t= 14°00'+0m 3d-(105°-110°21'12”)/15-12

t= 2°21'27.8”x15

t= 35°21'57”

Looking for the direction of the sun

Cotan A = tan x Cos ^x/ sin t – sin ^x/ tan t

Cotan A = tan 23°56'17” x cos 6°59'35”/ sin 35°21'57”- sin 6°59'35”/ tan 35°21'57”

= 53°51'36.87”

Calculate the azimuth of the sun

Because the declination at 14.00 is positive so

360° - sun direction = 360°-53°51'36.87”

= 306°8'23.13”

Calculating the data

Sun azimuth-180° = 306°8'23.13”-180°

= 126°8'23.13”

c. Measure the qibla direction at the location

Based on the data and the calculations produced by Mizwah.xls, it is known that Masjid Al-Ikhlas Ngaliyan has the Qibla azimuth 294 degrees, the azimuth of the sun's shadow when the measurement is at 14.00 so the measurement is :

1. Pay attention to the shadow formed by the gnomon, put the thread on the shadow.

2. Turn the plane of the dial on a scale of 162 degrees to the right of the thread.

3. Move the thread on a scale of 294 degrees, namely the Qibla azimuth number.
4. Mark the direction with thread or duct tape as the Qibla direction.

We also can measuring the Qibla direction using Mizwala by looking for the difference between the Qibla azimuth and the sun's azimuth. The steps are as follows:

1. Rotate the plane of the dial so that the 180-degree scale is exactly in the center of the shadow. use the guide lines on the dial area.
2. Calculate the azimuth of the sun by subtracting the azimuth of the sun's shadow (mizwah) by 180 degrees

   Azimuth of the Sun = mizwah-180 °

   = 162°-180 °

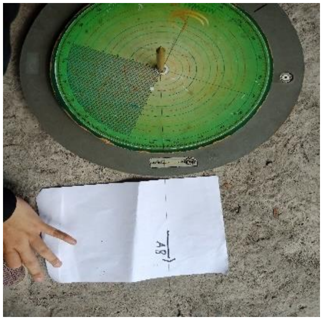
   =-18°
3. Calculate the difference between the Qibla azimuth and the sun azimuth to get the Qibla direction

   Qibla direction = Sun Qibla azimuth

   = 294°-(-18°)

   = 312°

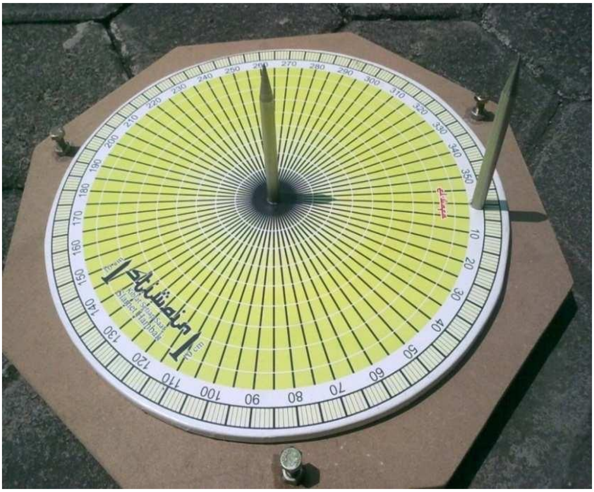
4. Pull and position the thread on the 312 degree scale.
5. Mark the direction with thread or duct tape as the Qibla direction.



D. Find Out The Qibla By USING Istiwa'aini

1. The definition of Istiwa'aini

Istiwaaini is a simple astronomical instrument consisting of two istiwa' sticks, where one is at the center of the circle and the other is at the 00 point of the circle. Istiwaaini which is also used to find out the qibla. It is designed with the same concept as the method of determining the Qibla direction with two right triangles from the Sun's shadow at any time. Determining the Qibla direction using Istiwaa is easier and more practical because this tool has designed the following scale so that there is no need for an arc to calculate the Qibla azimuth and Sun azimuth angles because there is already a dial area that has a scale.[7]



Istiwa'aini bySlamet Hambali[8]

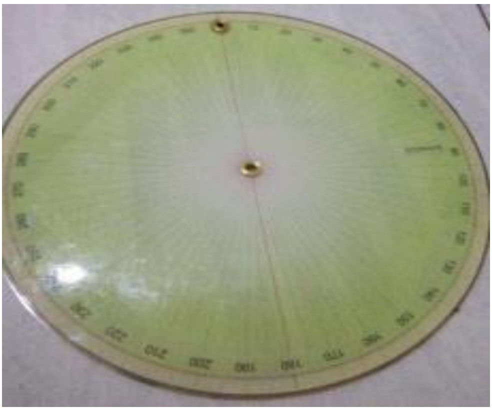
2. The components of Istiwa'aini
   a. Two special sticks, the stick at the center of the circle serves as a reference for the angles in the circle, and the thread reference as a guide to the Qibla direction, true north and others. While the stick which is at 0° has a function as a sight for the position of the sun as

[7] Muhammad Adieb, *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite*, (*Undergraduate thesis)*.UIN Walisongo Semarang: 2014

[8] Ibid,

well as a starter to measure the Qibla direction, and the true north from the sun's position.

b. The dial plane, this special dial has been designed for a 360-degree scale. The dial area serves as a catcher for the sun's shadow produced by the gnomon.



c. Tripod, is used to adjust the level of the thimble dial so that the istiwak stick can stand upright on it. The tripod in this istiwaa has a size of about 2.6 cm.

d. Yarn, is used to draw the Qibla line drawn from the istiwa' stick which is at the center point towards the number or number of the azimuth difference between the Qibla azimuth and the sun's azimuth. This long thread is used as a ruler to get the true north or kblat direction.

3. How to Use Istiwa’aini properly

There are several steps which must be taken to get accurate results. The steps are as follows:

a. Prepare the complete package of Istiwa’aini include waterpass and GPS/Google earth.
b. Prepare the required data, as follows:

- Latitude (ϕ^x),Longitude (λ^x), Longitude (λ^d) and Time of Measurement (WD)
- Qibla direction and Qibla azimuth, which is obtained through the following formula:

  AQ= Qibla direction

  ^m= latitude of the kaaba

  SBMD = the difference in longitude between the Kaaba and the place of measurement.

  Cotan AQ= tan ϕ^m x cons ϕ^x /sin SBMD - sin ϕ^x / tan SBMD

  The latitude and longitude of the Kaaba is 21°25'20.99" North Latitude and 39°49'34.36". This data is taken from google earth. The Qibla direction is measured from north to west. To get the Qibla azimuth the formula is, Qibla azimuth= 360°-AQ.

c. The direction of the sun and the azimuth of the sun

These data are obtained by taking astronomical data including declination and the equation of time according to the ephemeris table. The formula for the direction of the sun is:

Cotan AM= tan δ x cos ϕ^x/sin t-sin ϕ^x/tan t

AM = direction of the sun

(δ)= Declination at the time of measurement

t= (WD+e-(λ^d-λ^x)/15)-12x15

t = solar time angle, which can be obtained by the formula :

(λ^x)=Longitude of place

(λ^d)=Region longitude

(e)=Equation of time

You need too care some things for the sun direction, those are :

- If the declination is (+) then the direction is north.
- If the declination is (-) then the direction is south.
- If the measurement is morning, then the direction is east.
- If the measurement is afternoon, then the direction is west.

The sun azimuth (〖Az〗 _0) is determined by the formula:

- If the sun's direction is north-east, Az〗 _0 = sun's direction
- If the sun is south east, Az〗 _0 = 90°+sun direction
- If the sun is south west, Az〗 _0 = 180°+sun direction
- If the direction of the sun is north west, Az〗 _0=270°+ is the direction of the sun.

The difference between the Qibla azimuth and the sun azimuth, this data is obtained by the formula :
The azimuth of the sun's qibla. If the azimuth difference is negative, the azimuth difference must be added 360°.

d. Record the measurement time

After calculating the data, record the measurement time, Qibla azimuth, sun azimuth and azimuth difference. Put istiwaaini on the flat ground place which has enough sunlight. When istiwaani has been placed in a flat place, position the istiwa' stick at the center of the circle so that it is really at the center and in a vertical position. While the stick istiwa' which is at the point 0° in a vertical position as well. The circle that is used as the basis for the two istiwa' sticks (dial plane) must be completely in a flat position (horizontal). The flatness of the dial is measured using a waterpass. If it is not yet level, use three threads (nuts) to raise or lower it as needed until the dial is completely level and the two sticks are perfectly perpendicular. If this feature has been installed properly, watch the clock until the calculated hour of measurement arrives. When the calculated hour of measurement arrives, rotate the dial until the shadow of the special stick at 0° (on the edge of the circle) points directly to the main stick in the center of the circle. Thus the shadow of the stick is the opposite of the azimuth of the sun. Pull the thread from the center of the loop and position the thread at different azimuth values. The direction shown by the thread is the Qibla direction. Mark the direction with thread or duct tape as the Qibla direction.

4. Find out the qibla by using Istiwa'aini

Example for the calculation:

Location : Masjid Al-Ikhlas BPI, Ngaliyan, Central Java

Latitude (ϕ^x) = 6°59'35"

Longitude of place (λ^x)= 110°21'12"

Longitude (λ^d)=105° (Wib)

Kaaba latitude (ϕ^m)= 21°25'20.99"

Mecca Longitude (λ^m)= 39°49'34.36"

Measurement Time (WD)=14.00

Declination At the time of measurement (δ)= 23°56'17"

Equation of time (e)= 0m 3d

SBMD = longitude of place- longitude of mecca

= 110°21'12"-39°49'34.36"

= 70°31'37.64"

Look for the Qibat direction and Qibla azimuth

Cotan AQ= tan ^m x cos ^x /sin SBMD -sin ^x / tan SBMD

Cotan AQ = tan 21°25'20.99" x cos 6°59'35"/ sin 70°31'37.64"- sin 6°59'35"/ tan 70°31'37.64"

= 68°17'1.91"

Qibla Azimuth = 360°-AQ

= 360° - 68°17'1.91"

= 291°42'58”

Find out the direction of the sun and the azimuth of the sun

t= WD+e-(λ^d-λ^x)/15-12=…..x15

t= 14°00'+0m 3d-(105°-110°21'12”)/15-12

t= 2°21'27.8”x15

t= 35°21'57”

Cotan AM= tan x cos ^x/sin t-sin ^x/tan t

Cotan AM= tan 23°56'17” x cos 6°59'35”/sin 35°21'57”-sin 6°59'35”/tan 35°21'57” = 53°51'36.87"

Then the azimuth of the sun is :

The declination (+), so the direction is north

Measurements are taken in the afternoon, so the direction is west, so it means using the north-west formula:

Az〗_0=270°+59°28'11” = 323°51'36.8”

Then find out the difference in azimuth with the formula:

Difference azimuth = Qibla azimuth – sun azimuth

= 291°42'58”-323°51'36.8”

= -32°8'38.8”

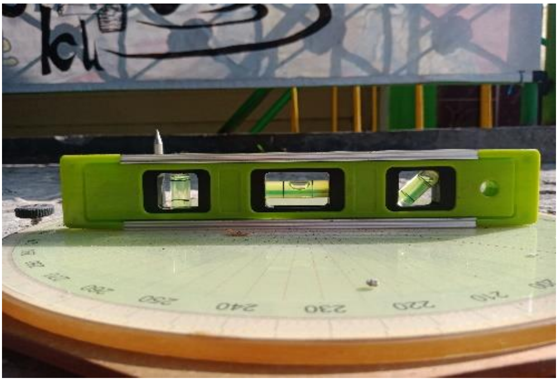
= 360°+-32°8'38.8”

= 327°51'21.2”

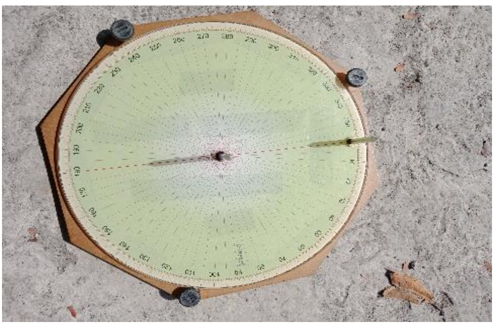
5. The measurement at the location

Based on the data which we has collected above, it is known that Qibla azimuth of Masjid Al-Ikhlas is 291°42'58". The direction of the sun when measuring at 14.00 WIB is 53°51'36.87", and the sun's azimuth is 323°51'36.8" . So here are the steps of the measurement:

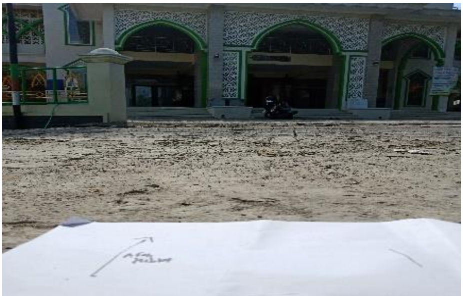
a. Place and Flatten Istiwa’ain by turning the tripod in the form of a nut located on the three parts of the tool, then check the ground using water.



b. Rotate the dial until the wand's shadow is at 0°(on the edge of the circle pointing directly to the main stick in the center of the circle. The wand's shadow is the opposite of the sun's azimuth.



c. Pull the thread from the center of the circle and position it at the different azimuth data (327°51'21.2"), the direction the thread is showing is the Qibla direction.



d. Mark the direction with thread or duct tape as the Qibla direction.

CHAPTER IV
THE COMPARISON OF MIZWALA AND ISTIWA'AINI AS QIBLA FINDER

A. Analysis of Mizwala and Istiwa'aini as Qibla Finder

1. Mizwala

    Mizwala Qibla Finder which is created by Hendro Setyatno is actually simple to use even though we need to calculate the astronomical formula first to collect the data before measuring the location where we want to know the qibla but it doesn't meant that everyone can use it easily without learning and practicing how to use it. Mizwala has several main components those are *gnomons, the swivel dial area, and the level field*. As I have written above, Mizwala is simple and easy to use but it does not mean that everyone can operate it well. So that for the ordinary people it is not difficult but also not easy to practice. Here is the steps how to use Mizwala :

    1. Prepare mizwala qibla finder, rope/thread with a length of ± 1 meter (according to needs), and GPS.
    2. Prepare the required data, namely latitude, longitude, date and time of measurement. To find out latitude, longitude and time data, it is recommended to use GPS or Google Earth.

3. Run the Mizwah.xls software on a computer, laptop, notebook or smart phone which supports the program. Then input the data needed in the Mizwah.xls table according to the provided column, including time zone data, latitude, longitude, measurement date, measurement time, and time interval which will be displayed. After that, we will get the Qibla azimuth data (qibla column), sun azimuth data (as-simtu column) and sun shadow azimuth (mizwah column).
4. Record the position of the sun (column as-simtu), the shadow of the gnomon (mizwah) and the direction of the Qibla at the hour to be measured.
5. Place the mizwala qibla finder in a flat place and get sunlight. Then place the waterpass over the mizwala to measure the flatness of the level plane. If it is not flat, it can be adjusted by turning the tripod until it is balanced or flat. Then tie the rope / thread that has been prepared on the gnomon to mark the shadow that will be obtained later.
6. If Mizwala is installed properly, pay attention to the shadows on the gnomon on the dial plane then record the observation time used to mark the shadows obtained later.

7. Place the tied thread on the gnomon and pull it in the direction of the gnomon's shadow.
8. Rotate the dial until the mizwah data is just below the thread or shade. Mizwah data is adjusted to the time of shooting or measurement.
9. Move the thread to the Qibla direction data listed in the mizwah table.
10. After the thread is pulled straight according to the Qibla azimuth data, then that direction is the Qibla direction where the observer is,

Mizwala can be used everywhere as long as there is enough sunlight and the the measurement result of it is also accurate but it is heavy enough to carry to any location where we want to check the qibla. So it is not practical enough to use as qibla finder for some situations and condition.

2. Istiwa'aini

Slamet Hambali explained Istiwa'aini is a simple tool consisting of two istiwa' sticks, one stick is at the center of the circle and the other is at the 00 point of the circle. The measurement of the Qibla direction using Istiwa'ini is basically the same as the measurement using any other qibla finder such as Mizwala, which requires the following data. It needs:

1. The latitude of the location where the Qibla will be measured,

2. Longitude of the place,
3. Kaaba latitude
4. and Kaaba longitude.

Here are the steps how to use Istiwa'aini :

1. Flatten Istiwa'aini by turning the tripod in the form of a nut located on the three parts of the tool, then check the ground using a water fitting.
2. Rotate the dial until the wand's shadow is at 0°(on the edge of the circle pointing directly to the main stick in the center of the circle. Thus the wand's image is the opposite of the sun's azimuth.
3. Pull the thread from the center of the circle and place it at the different azimuth data, the direction the thread is showing is the Qibla direction.
4. Mark the direction with thread or duct tape as the Qibla direction.

In Almanac, it is stated that Kaaba is located at 390 50 'E with latitude + 210 25'. In 1994, Nabhan Masputra performed the pilgrimage with a Global Positioning System (GPS), Kaaba longitude was 390 49' 40 "and the Kaaba latitude +210 25' 14.7". Information from Boscha, it is said that Ibrahim also conducted research using the Global Positioning System, obtained BT Kaaba 390. The use of Istiwa'ani in determining the direction of Qibla is to pull the thread by the difference in azimuth, namely the Qibla azimuth minus the azimuth of the Sun. Finding the data of the azimuth of the sun requires the data of the declination of the sun, 13 equation of time, 14 angles of solar time, 15 and the direction of the sun. This kind of calculation is known as the concept of spherical trigonometry theory to find out the direction of Qibla use spherical triangle formulas to determine the angle formed from two points above the Earth.

Istiwa'aini and Mizwala have similarity for their working principle, that is they can not be used when there is no sun light or in rainy season. Although Istiwa'aini is not so big as any other astronomical instruments but it is also heavy enough to carry from one place to other places. It means Istiwa'aini is also not practical to use in some situations and condition. It is the same like what I have written about Mizwala before. In addition, the fifth-degree scale on the dial area causes difficulty to measure if the calculation results are up to seconds. In determining the seconds in this special field, only by estimating.

Then The yellow color chosen on the Istiwaaini dial area causes dim or dark eyes when entering the room after using Istiwaaini. This is presumably because yellow does not absorb light, so light reflects off the eyes. It would be better if it was designed a little dark but still consider the lines and scale to keep it clear.[1]

B. Comparison of Mizwala and Istiwa'aini as Qibla Finder

To know how the comparison of Mizwala and Istiwa'aini as qibla finder is, it means you need to do the calculation to get the data then do the measurement in the same location by using both tools. The researcher actually has written every calculation completely in chapter 3 but it is not written yet for the comparison so the researcher would like to write it once more in this chapter specifically.

- Location : Masjid Al-Ikhlas, BPI,Ngaliyan, Central Java.
- Time : 14.00 WIB

Image 4.1 Masjid Al-Ikhlas BPI, Ngaliyan

[11] Muhammad Adieb, *Studi Komparasi Penentuan Arah Kiblat Istiwqaaini Karya Slamet Hambali dengan theodolite*, *(Undergraduate thesis)*. UIN Walisongo Semarang: 2014, p.65-67

- Calculations and Measurements :

1. *Mizwala Measurement*

Latitude (ϕ^x) = 6°59'35"

Longitude of place (λ^x)= 110°21'12"

Longitude (λ^d)=105° (Wib)

Measurement Time (WD)=14.00

Declination At the time of measurement (δ)= 23°56'17"

Equation of time (e)=0m 3d

Find out the sun's time angle

t= WD+e-(λ^d-λ^x)/15-12=…..x15

t= 14°00'+0m 3d-(105°-110°21'12")/15-12

t= 2°21'27.8"x15

t= 35°21'57"

Look for the direction of the sun

Cotan A= tan x Cos ^x/ sin t – sin ^x/ tan t

Cotan A= tan 23°56'17” x cos 6°59'35”/ sin 35°21'57”- sin 6°59'35”/ tan 35°21'57” =53°51'36.87”

Calculating the azimuth of the sun

Since the declination is positive at 14.00 so the formula is 360°- sun direction = 360°-53°51'36.87”

= 306°8'23.13”

Calculating the data

Sun azimuth-180° = 306°8'23.13”-180°

= 126°8'23.13”

By the calculation, it is known that Qibla azimuth data is 294 degrees, the azimuth of the sun's shadow when measuring at 14.00 WIB is 162 degrees.So the measurement is :

(mizwah) with 180 degrees

Azimuth of the Sun = mizwah-180°

= 162°-180°

=-18°

Calculate the difference between the Qibla azimuth and the sun azimuth to get the Qibla direction.

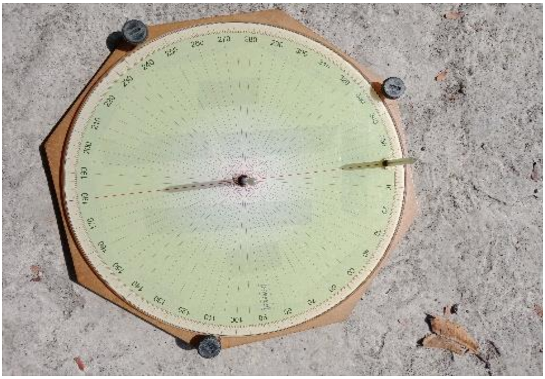
Qibla direction = Sun Qibla azimuth = 294°-(-18°)

= 312°

Pull and position the thread on the 312 degree scale.

Mark the direction with thread or duct tape as the Qibla direction

2. *Istiwa'aini*



Latitude (ϕ^x) = 6°59'35"

Longitude of place (λ^x) = 110°21'12"

Longitude (λ^d) =105° (Wib)

Kaaba latitude (ϕ^m) = 21°25'20.99"

Mecca Longitude (λ^m) = 39°49'34.36"

Measurement Time (WD) =14.00

Declination At the time of measurement (δ)= 23°56'17"

Equation of time (e)= 0m 3d

SBMD = longitude of place- longitude of mecca

= 110°21'12"-39°49'34.36"

= 70°31'37.64"

Looking for Qibat direction and Qibla azimuth

Cotan AQ = tan ^m x cos ^x /sin SBMD -sin ^x / tan SBMD

Cotan AQ = tan 21°25'20.99" x cos 6°59'35"/ sin 70°31'37.64"- sin 6°59'35"/ tan

70°31'37.64

= 68°17'1.91"

Qibla Azimuth = 360°-AQ

= 360°-68°17'1.91"

= 291°42'58"

Find the direction of the sun and the azimuth of the sun

t = WD+e-(λ^d-λ^x)/15-12=…..x15

= 14°00'+0m 3d-(105°-110°21'12")/15-12

= 2°21'27.8"x15

= 35°21'57"

Cotan AM = tan x cos ^x/sin t-sin ^x/tan t

Cotan AM = tan 23°56'17" x cos 6°59'35"/sin 35°21'57"-sin 6°59'35"/tan 35°21'57"

= 53°51'36.87"

Then the azimuth of the sun is:

The declination (+), so the direction is north

The measurement is sick, so the direction is west

That is, using the north-west formula:

Az〗_0 = 270°+59°28'11"

= 323°51'36.8"

Then find the difference in azimuth by using this formula below :

Difference azimuth = Qibla azimuth – sun azimuth

= 291°42'58"-323°51'36.8"

= -32°8'38.8"

= 360°+-32°8'38.8"

= 327°51'21.2”

The result of the calculation is

Qibla azimuth : 291°42'58"

Direction of the sun when measuring at 14.00 WIB is 53°51'36.87", and the sun's azimuth is 323°51'36.8" . So the measurement is pull the thread from the middle of the circle and position it at the different azimuth data (327°51'21.2"), the direction the thread is showing is the Qibla direction. The difference of qibla direction of both tools is less then 1,5 degrees means it is accurate still based on Istiwaini and theodolite even has only less than 2 degrees. It means the position of qibla is the same accurate when it is determining using Mizwala or Istiwa’aini.

Mizwalla and Istiwaaini as classical *rukyah* instruments have several strengths, those are:

1. Simple and easy to use.
2. Can be used everywhere and anytime as long as there is sunlight.
3. Can be owned at an affordable price.
4. The short tripods on the two tools make it easy to pull the thread to mark the Qibla azimuth and sun azimuth lines to determine true north.

In addition to have several advantages, both also have some weaknesess including:

1. Mizwalla and Istiwaaini cannot be used when the weather is cloudy or the sun is being blocked by something and at night.
2. Cannot be used on sloping ground.
3. It is often happened for human error in placing marks on the dial plane line, because of the bolt on the gnomon, making it difficult to mark the shortest shadow length on the lines in the dial plane.
4. There is no cm or even mm scale on the Mizwalla and Istiwa'aini dial planes which are used to determine the length of the shortest image, as well as the length of the shadows at the time of Asr and Zuhur.

CHAPTER V

CLOSING

A. Conclusion

Based on the explanation about Mizwala and Istiwa'aini as qibla finder so we can conclude that :

1. Mizwala and Istiwa'aini is accurate to find out the qibla but we need to collect the data as well as possible before measuring the qibla direction in the location where the research will be conducted. In addition they only can be used at day time because their working principle is using the sunlight. Both Mizwala and Istiwa'aini are heavy so these instruments are not practical enough to carry anywhere.
2. The comparison results of the qibla direction measurement between mizwala and Istiwa'aini is less than 1.2 degrees, It means they are suitable to be used as qibla finder because based on research from previous researcher who compared Istiwa'aini with theodolite, it turns out that the difference is less than two degrees. It means Istiw'aini can not only be used as comparison in this thesis but also has function as a parameter.

B. Suggestion

In the future, if it is possible, it will be better if the creator of any astronomical instruments will not only think about the accuracy result which can be processed but also think properly about the design of the instruments they create because it is also important and can effect the result of the measurement.

C. Closing

Thank you God for the help and everything You do for me so that I could finish the thesis properly even though I had to face a lot of difficulties while struggling to finish it. Thanks also to everyone who have helped me so far during the hard situation when I was on process to maintain my study. It was hard but finally I did it. I hope it will be able to be useful and helpful for the readers. I apologize to you if there are still many weaknesses of my writing which you find accidentally here. Thank you for constructive criticism and suggestions.

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BIOGRAPHY

Lusiana Dwi Ariani was born on January, 9, 1994 in Jepara, Central Java. She is the first daughter of Sudaryo and Endang Purwanti. She lived in Dermolo Dombang, Jepara but then she has been moving to Semarang currently since she studies at UIN Walisongo Semarang. She studied at SD.N Dermolo 03 for the primary school around 2000-2006 then continued her secondary school at SMP.N 01 Keling in 2006-2009, after that she continued her study to high school at SMA Muhammadiyah 01 Bangsri in 2009-2012. After graduated from high school, Ana (the writer's nickname) did not continue her study to the next level immediately but she decided to study English at Basic English Course in Pare, East Java for about 1,5 year then she spent her other six months for traveling around Java because she is a big fan of traveling. After two years since she graduated from high school then she decided to take Bachelor Degree at UIN Walisongo Semarang. Her journey when studying at university was absolutely not easy. She accidentally took the subject which she did not have any idea at all about it but she did not give up even though she had to face such uncountable complicated issue when she was trying hard to adapt with the new environment at campus specially for the Islamic Astronomy (the subject/major she took). She was an active student, she joined some intra and extra organization of the campus. She has also ever got a great opportunity to join Student Mobility Programme which was conducted at Deakin University, Australia in 2016. She is not only a big fan of traveling but also a big fan of writing specially writing poem. Studying at UIN Walisongo is really another level of challenge of life for her. It is truly hard for her but finally she could finish her study in 7,5 years.