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Analysis of Advantages Data on Hijri Year Compared AD Year through Wind Speed Climate Modeling

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ABSTRACT: The Gamma and Weibull distribution models were used for modeling wind speed data in the AD years and Hijri years. This study aims to determine the best model for wind speed data using Gamma and Weibull distributions. The research data used is wind speed data in the AD year from January 1999 to March 2019 and the Hijri year 1420-1440 at Tabing Airport, West Sumatera. This study showed that the Gamma distribution model was more suitable for wind speed data in 1420-1440 Hijri year than the Weibull distribution. This is shown from the results of the AIC Aikake's Information Criterion) test, which shows that the AIC value for the Gamma distribution is smaller than the AIC test results on the Weibull distribution value, while the Gamma distribution AIC value for the Hijri year data is smaller than the AD year data for the Gamma distribution.

KEYWORDS: wind speed data, Gamma distribution, Weibull distribution.

1. INTRODUCTION

Differences in time calculation systems in the AD year and Hijri year can indirectly give different conclusions from a study that uses data on the time of occurrence of the same event. The AD year based on the solar system and the Hijri year based on the lunar system will result in a significant shift in data in analyzing an event [1]. Climate change research is a study that is highly dependent on the time of a particular event. Wind speed events, floods, and droughts are some exciting events to study in the issue of climate change. Wind speed events, floods, and droughts are exciting events to study in the issue of climate change [4]. The use of daily time data to research wind speed is research in the field of climate change that is very useful in everyday life [11].

The study stated that the pattern of wind speed and the nature of the wind speed in the months of the AD year had different properties and characteristics. Research results showing different trends in forecasting wind speed every month in the AD year [14]. The studies above focus on producing the best wind speed modeling to predict the pattern or characteristics of wind speed in the future. The model's goodness will be tested through the lowest possible error rate. In other words, the resulting models will be judged the best if they produce the slightest error.

In this study, another approach will be taken in producing a wind speed model, where the daily wind speed data measured through AD year will be transformed into daily wind speed data in the Hijri year. The difference in the time calculation system for the two years will be used to show changes in the accuracy of the wind speed model, and this can also mean that the use of wind speed data that has been converted into the Hijri year is assumed to produce better model accuracy or vice versa. The wind speed model used in this research is theoretically perfect for producing wind speed forecasts that will occur in the future [6].

This research aims to produce the best model for the time type (AD year and Hijri year). Moreover, produce a more accurate model in analyzing wind speed data by referring to the smallest error value for the two types of time given. This research is expected to provide an overview of wind speed data to institutions that need information on wind speed data modeling in producing forecasts for wind speed data that apply in the future [3]. Government agencies such as the Ministry of Agriculture and Forestry are government agencies that need accurate wind and rain speed information. No research discusses modeling using statistical distributions for wind speed data using two times, namely the AD year and the Hijri year. Therefore, researchers are interested in discussing statistical distribution modeling using data two times.

2. METHODS

Many studies examine wind speed data, including which examines wind speed events, floods, and droughts as interesting events to study in the issue of climate change [4]. [11] Discuss the use of daily time data to research wind speed is research in the field of climate change that is very useful in everyday life. The study stated that the pattern of wind speed and the nature of the wind speed in the months of the AD year had different properties and characteristics. Research results showing different trends in forecasting wind speed every month in the AD year [14].

In this study, the author explicitly examines how to compare statistical models for wind speed data using daily data from the AD year and Hijri year. The wind is the movement of air parallel to the earth's surface [8]. Air moves from areas of high pressure to areas of low pressure. Winds are named according to which direction the wind comes; for example, the east wind is the wind that comes from the east, the sea breeze is the wind from the sea to the land, and the valley wind is the wind that comes from the valley up the mountain [13].

Wind or wind speed is a fascinating natural phenomenon to be studied or researched so that this natural phenomenon has been stated clearly in the Qur'an. Allah mentions the word wind in the Qur'an. The wind is described in many verses of the Qur'an, including Surah Al Baqarah verse 164 and Surah Al Kahf verse 45 [16], [17]. Based on Surah Al Baqarah verse 164 tells about the formation of wind or wind speed; this will be revealed again using a scientific approach to be formulated into a science of science in modern times. In depth research on wind speed data has succeeded in leading scientists to engineer the cycle so that it can be used to assist farmers in determining where to plant crops. This research is rarely done, especially in revealing the difference in the AD year and Hijri year, which is applied in a wind speed data model. The explanation of the difference between the AD year and Hijri year will begin a literature review, followed by an explanation of the conversion of time from the AD year into the Hijri year and closes with an explanation of several models that will be used in this model and the techniques for testing the accuracy of the resulting model [2].

A. The AD Year and Hijri Year

The average solar journey in one year takes 365.25 days. This solar system is used as the basis for determining the AD calendar. At the same time, the moon’s journey in one year takes 354.37 days. This lunar system is used as the basis for determining the Hijri calendar. These two universally applicable calendars have a difference of 11 days in one year [16], [17]. How to convert the AD year into the Hijri year can be done as follows:

a. The date, month, and year of Christ are converted into days using the following procedure:
   - Calculate the whole month and year (tam) by subtracting one each (-1)
   - The whole year is divided by 4; then the result is multiplied by (x) 1461; if there is a remainder from the division, the remainder is multiplied by (x) 365 days.
   - Numbers of months and dates are made into days according to the age of the AD month.

b. The total number of days minus (-) the difference between the AD year and the Hijri year is 227,016 days, and the AD XIII budget is 13 days.

c. The result of the subtraction (point b) is converted into the Hijri date, month, and year by:
   - The total number of days is divided (:) 10,631, then from the result of the division, the whole number is multiplied by (x) 30, to get the number of years in the Hijri year cycle that has taken place, whereas if there are remaining days divided (:) 354 and subtracted (-) the number of leap years in the remaining years.

d. To find the day and market in the Hijri year in the following way:
   The total number of days is divided by (:) 7 (seven), the rest is calculated from Friday, namely: 1=Friday, 3=Sunday, 5=Tuesday, 7=Thursday, 2=Saturday, 4=Monday, 6=Wednesday, 0=Thursday.

B. Wind Speed Climate Modeling with Gamma Distribution

The daily wind speed data used in the AD year and Hijri year using Gamma and Weibull distributions. A random variable X is said to have a Gamma distribution with parameters $\alpha > 0$ and $\beta > 0$ if and only if the probability density function of X is [7]:

$$f(x) = \frac{x^{\alpha-1}e^{-x/\beta}}{\beta^{\alpha}\Gamma(\alpha)}, 0 \leq x < \infty \ with \ \Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1}\, e^{-x} dx$$

The quantity $\Gamma(\alpha)$ is known as the Gamma function. The direct integral will produce $\Gamma(1) = 1$. Continually the integral will result in $\Gamma(\alpha) = (\alpha-1)\Gamma(\alpha-1)$ in that for $\alpha > 1$, and also
$\Gamma(n) = (n-1)!$ its result if n is an integer. The proof of equation can be shown are:

$$\Gamma(\alpha) = \int_0^{\infty} x^{\alpha-1}\, e^{-x} dx = \left[-x^{\alpha-1}e^{-x}\right]_0^{\infty} + \int_0^{\infty} (\alpha-1)\, x^{\alpha-2} e^{-x} dx = (\alpha-1)\int_0^{\infty} x^{\alpha-2} e^{-x} dx = (\alpha-1)\Gamma(\alpha-1)$$

Gamma distribution is a continuous distribution that can solve many problems in engineering and science. For example, Gamma distribution plays a vital role in queuing and reliability theories, overcoming data loss. The Gamma distribution has the following probability density function:

$$f(x) = \frac{x^{\alpha-1}e^{-\frac{x}{\beta}}}{\beta^{\alpha}\Gamma(\alpha)}$$

C. Wind Speed Climate Modeling with Weibull Distribution

The Weibull distribution is taken from a physicist from Sweden named Waloddi Weibull in 1939. The Weibull distribution is a distribution that is often used because it describes the entire data clearly, especially in testing and modeling data, so the Weibull distribution is often applied for modeling, including modeling in the field of technology. Wind speed, chemical elements, and also in the field of hydrology. The characteristics of the Weibull distribution are characterized by two parameters λ and γ, where $\lambda > 0$ and $\gamma > 0$.

The Weibull distribution is a continuous random distribution that also has the following probability density function [7], [9]:

$$f(x) = \lambda\gamma(\lambda x)^{\gamma-1}e^{-(\lambda x)^{\gamma}}$$

with the expected value and successive variance is $\frac{\Gamma\left(1+\frac{1}{\gamma}\right)}{\lambda}$ and $\frac{1}{\lambda^2}\left[\Gamma\left(\frac{2}{\gamma}+1\right) - \Gamma(1+\frac{1}{\gamma})^2\right]$, while the cumulative distribution function is $F(x, \lambda, \gamma) = 1 - e^{-(\lambda x)^{\gamma}}$.

D. Parameter Estimation

The distribution parameters must first be determined in determining the appropriate probability density function model for data. One of the methods used is the maximum likelihood method. The maximum likelihood method is often used in research because the procedure or steps are apparent and appropriate in determining the parameters of a distribution [7], [10].

E. Wind Speed Data

The data in this study are daily wind speed data obtained from the West Sumatra Tabing station, which is managed by the National Oceanic and Atmospheric Administration (NOAA) website. This daily data is measured using the AD year from January 1999 to March 2019. The data collection method used is by taking secondary data on the National Oceanic and Atmospheric Administration (NOAA) website.

F. Data Analysis Method

Statistical modeling research is very dependent on the availability of many data. For this reason, in this study, daily wind speed data was obtained from the West Sumatra Tabing station managed by the National Oceanic and Atmospheric Administration (NOAA) website. This daily data is measured using the AD year from January 1999 to March 2019. The adequacy of the amount of available data will be followed by data adjustments or initial data processing by the model to be carried out; therefore, the wind speed data that has been obtained during the AD year will be converted into wind speed data the Hijri year. This conversion can be done manually using the procedures discussed previously or digitally through the help of software tools; in this case, software converting AD year data into Hijri year will be used in this study.

The data adapted to these needs will run wind speed models in this study. Two wind speed data models, namely the Gamma probability density function and the Weibull probability density function, will be applied using daily wind speed data in the AD year and Hijri year. The accuracy will determine the success of running the two models above in estimating the parameter values generated by the two models used in this study. The accuracy of the estimation of this model will be guaranteed by an excellent technique known as the likelihood method.

They are closing the modeling testing the goodness of the resulting model. For this reason, the two models used by going through two types of data (AD year and Hijri year) will be tested using the AIC (Akaike Information Criterion) method. The smallest AIC value can be used in selecting the best model from the available data types (AD year and Hijri year). The best-decided model will be used in forecasting daily rainfall values for the future. The model's goodness will be explored, especially the advantages and disadvantages of the best model produced.

3. RESULTS

3.1 Overview of Wind Speed Data in the AD year and Hijri year

An overview of the wind speed data in the AD year and Hijri year in the graph:

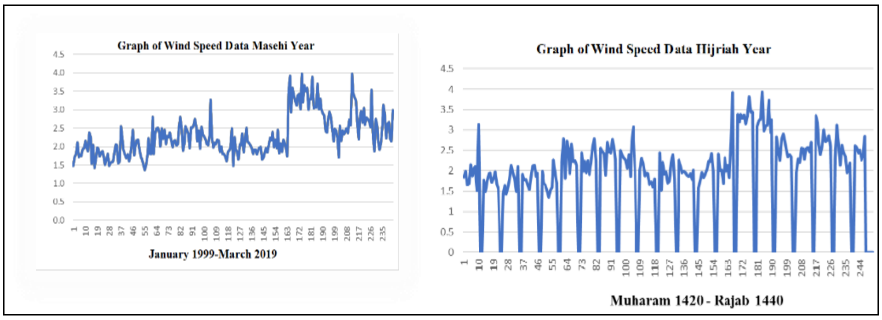


Fig. 1. The plot of Wind Speed Data in the AD Year and Hijri Year in West Sumatra

Descriptive analysis of wind speed data for the AD year and Hijri year in West Sumatra taken daily from January 1999 to March 2019 and the Hijri year Muharam 1420H to Rajab 1440H is shown in the following table:

Table 1. Descriptive Statistics of Wind Speed Data in the AD Year and Hijri Year

Descriptive Statistics for Wind Speed Data AD Year	
N	243
Average	2.3
Standard Deviation	0.56
Maximum Value	4.0
Descriptive Statistics for Wind Speed Data Hijri Year	
N	252
Average	2.3
Standard Deviation	0.53
Maximum Value	3.9

3.2 Parameter Estimation using Maximum Likelihood Method

The maximum likelihood method is one of the methods used in determining the parameters of a distribution. In this study, this method will be used to determine the parameters of the Gamma and Weibull distributions [7].

3.3 Gamma Distribution Parameter Estimation

The parameters of the Gamma probability density function (α, β) can be shown as follows [7], [10]:

$$f\ x,\alpha,\beta = \frac{x^{\alpha-1}e^{-\frac{x}{\beta}}}{\beta^{\alpha}\,\Gamma\ \alpha}, x\ \geq 0$$

so that it can produce the likelihood function, namely:

$$L = f\ x_1\ f x_2 \ldots f x_n = \frac{x_1^{\alpha-1}exp-\frac{x_1}{\beta}}{\beta^{\alpha}\,\Gamma\ \alpha}.\frac{x_2^{\alpha-1}exp-\frac{x_2}{\beta}}{\beta^{\alpha}\,\Gamma\ \alpha}\ldots\frac{x_n^{\alpha-1}exp-\frac{x_n}{\beta}}{\beta^{\alpha}\,\Gamma\ \alpha} = \frac{\prod_{i=1}^{n}\ x_i^{\alpha-1}exp-\sum_{i=1}^{n}\frac{x_i}{\beta}}{\beta^{\alpha n}\,\Gamma\ (\alpha)^n}$$

After obtaining the likelihood function, the maximum likelihood will be determined from the above equation by converting the likelihood function into the logarithm of likelihood, namely [7], [11]:

$$l = logL = log\Pi_{i=1}^{n}x_i^{\alpha-1} + \log\exp - \sum_{i=1}^{n}\frac{x_i}{\beta} - log\beta^{\alpha n} - log\Gamma(\alpha)^n$$
$$= \alpha - 1\sum_{i=1}^{n} logx_i - \sum_{i=1}^{n}\frac{x_i}{\beta} - n.\alpha\ log\beta - logn - log\ \Gamma(\alpha)$$

In determining the estimated value of α and β, the above equation can be partially derived from the two parameters so that it is obtained as follows:

- The first and second partial derivatives of the alpha parameter:

$$\frac{\partial l}{\partial\alpha} = \sum_{i=1}^{n} log\ x_i - n\ log\ \beta - \frac{\Gamma'(\alpha)}{\Gamma(\alpha)} = 0$$
$$\frac{\partial^2 l}{\partial^2\alpha} = -n\frac{\Gamma''(\alpha)\Gamma(\alpha) - \Gamma'(\alpha)\Gamma'(\alpha)}{(\Gamma(\alpha))^2}$$

- The first and second partial derivatives of the beta parameter:

$$\frac{\partial l}{\partial\beta} = \frac{1}{\beta^2}\sum_{i=1}^{n} x_i - \frac{n\alpha}{\beta} = 0$$
$$\frac{\partial^2 l}{\partial\beta^2} = -2\beta^{-3}\sum_{i=1}^{n} x_i + n.\alpha.\beta^{-2}$$

3.4 Weibull Distribution Parameter Estimation

The parameters of the Weibull probability density function (λ, γ) can be shown in the following equation:

$$L = fx_1\, fx_2 \dots fx_n = \gamma^n \lambda^{n\gamma} \prod_{i=1}^{n} x_i^{\gamma-1}\, exp \sum_{i=1}^{n} -\lambda x_i{}^{\gamma}$$

After obtaining the likelihood function, the maximum likelihood will be determined from the above equation by converting the likelihood function into the logarithm of likelihood, namely:

$$l = logL = n\, log\,\gamma + n\gamma\, log\,\lambda + \sum_{i=1}^{n} \gamma - 1\, log\, x_i - \lambda^{\gamma} x_i^{\gamma}$$

because,

$$\frac{\partial(\lambda;\gamma)}{\partial\lambda} = 0$$

so that,

$$\frac{\partial l}{\partial \gamma} = \frac{n}{\gamma} + n\, log\,\lambda + \sum_{i=1}^{n} log\, x_i - \lambda^{\gamma} \sum_{i=1}^{n} x_i^{\gamma}\, log\,\lambda + log\, x_i = 0$$

3.5 Determining the Initial Parameter Value of the Gamma Distribution

After obtaining the parameter equations from the Gamma and Weibull distributions, the value of these parameters will be determined from the rainfall data. In determining the value of the Gamma distribution parameter using the likelihood method and Newton Raphson to approach the parameter value, because Newton Raphson requires an initial value, it is necessary first to know the relationship of the parameters to the data (mean and variance). This relationship can be expressed as follows:

$E\,(x) = \frac{\sum_{i=1}^{n}(x_i)}{n} = \frac{1378.7}{589} = 2.34$ and $V\,(x) = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1} = \frac{845.28}{588} = 1.44$

The value of the Gamma distribution parameters for the Hijri year from 1410 to 1429 and AD year from 1990 to 2008 can be seen in the table below:

Table 2. Initial Parameter Values for the Hijri and AD Years using the Gamma Distribution

Hijri Year	*Gamma*		AD Year	*Gamma*	
	α	**β**		**α**	**β**
Muharram	3.8114	0.6141	January	3.5021	0.6427
Safar	3.7035	0.6240	February	3.8494	0.6042
Rabiul Awal	4.0141	0.5499	March	4.9107	0.4770
Rabiul Akhir	29977	0.7375	April	4.1607	0.5336
Jumaidil Awal	4.2712	0.5336	May	3.4548	0.6238
Jumaidil Akhir	4.6022	0.4839	June	2.8797	0.7759
Rajab	4.3373	0.5254	July	4.0466	0.5363
Sya'ban	3.5335	0.6764	August	3.9631	0.6270
Ramadhan	3.5802	0.6399	September	3.6434	0.6900
Syawal	3.1223	0.7449	October	3.9961	0.6014
Dzulkaidah	3.7749	0.6449	November	3.6141	0.6586
Dzulhijjah	3.1141	0.7810	December	3.3110	0.6830

Based on the parameter values in Table 2 above, the Gamma distribution model for the wind speed data for each month of the Hijri and AD years is obtained as follows:

Table 3. Modeling Wind Speed for the Hijri and AD Years using the Gamma Distribution

No	Hijri Year	Model	No	AD Year	Model
1	Muharram	$f(x) = \frac{x^{(3.8114-1)} e^{-\left(\frac{x}{0.6141}\right)}}{(0.6141)^{3.8114}\Gamma(0.6141)}$	1	January	$f(x) = \frac{x^{(3.5021-1)} e^{-\left(\frac{x}{0.6427}\right)}}{(0.6427)^{3.5021}\Gamma(3.5021)}$
2	Safar	$f(x) = \frac{x^{(3.7035-1)} e^{-\left(\frac{x}{0.6240}\right)}}{(0.6240)^{3.7035}\Gamma(3.7035)}$	2	February	$f(x) = \frac{x^{(3.8494-1)} e^{-\left(\frac{x}{0.6042}\right)}}{(0.6042)^{3.8494}\Gamma(3.8494)}$

3	Rabi’ al-awwal	$f(x)=\frac{x^{(4.0141-1)}e^{-\left(\frac{x}{0.5499}\right)}}{(0.5499)^{4.0141}\Gamma(4.0141)}$	3	March	$f(x)=\frac{x^{(4.9107-1)}e^{-\left(\frac{x}{0.4770}\right)}}{(0.4770)^{4.9107}\Gamma(4.9107)}$
4	Rabi’ al-akhir	$f(x)=\frac{x^{(2.9977-1)}e^{-\left(\frac{x}{0.7375}\right)}}{(0.7375)^{2.9977}\Gamma(2.9977)}$	4	April	$f(x)=\frac{x^{(4.1607-1)}e^{-\left(\frac{x}{0.5336}\right)}}{(0.5336)^{4.1607}\Gamma(4.1607)}$
5	Jumadil al-awwal	$f(x)=\frac{x^{(4.2712-1)}e^{-\left(\frac{x}{0.5336}\right)}}{(0.5336)^{4.2712}\Gamma(0.5336)}$	5	May	$f(x)=\frac{x^{(3.4548-1)}e^{-\left(\frac{x}{0.6238}\right)}}{(0.6238)^{3.4548}\Gamma(3.4548)}$
6	Jumadil al-akhir	$f(x)=\frac{x^{(4.6022-1)}e^{-\left(\frac{x}{0.4839}\right)}}{(0.4839)^{4.6022}\Gamma(4.6022)}$	6	June	$f(x)=\frac{x^{(2.8797-1)}e^{-\left(\frac{x}{0.7759}\right)}}{(0.7759)^{2.8797}\Gamma(2.8797)}$
7	Rajab	$f(x)=\frac{x^{(4.3373-1)}e^{-\left(\frac{x}{0.5254}\right)}}{(0.5254)^{4.33737}\Gamma(4.3373)}$	7	July	$f(x)=\frac{x^{(4.0466-1)}e^{-\left(\frac{x}{0.5363}\right)}}{(0.5363)^{4.0466}\Gamma(4.0466)}$
8	Sya'ban	$f(x)=\frac{x^{(3.5335-1)}e^{-\left(\frac{x}{0.6764}\right)}}{(0.6764)^{3.5335}\Gamma(3.5335)}$	8	August	$f(x)=\frac{x^{(3.9631-1)}e^{-\left(\frac{x}{0.6270}\right)}}{(0.6270)^{3.9631}\Gamma(3.9631)}$
9	Ramadhan	$f(x)=\frac{x^{(3.5802-1)}e^{-\left(\frac{x}{0.6399}\right)}}{(0.6399)^{3.5802}\Gamma(3.5802)}$	9	September	$f(x)=\frac{x^{(3.6434-1)}e^{-\left(\frac{x}{0.6900}\right)}}{(0.6900)^{3.6434}\Gamma(3.6434)}$
10	Syawal	$f(x)=\frac{x^{(3.1223-1)}e^{-\left(\frac{x}{0.7449}\right)}}{(0.7449)^{3.1223}\Gamma(3.1223)}$	10	October	$f(x)=\frac{x^{(3.9961-1)}e^{-\left(\frac{x}{0.6014}\right)}}{(0.6014)^{3.9961}\Gamma(3.9961)}$
11	Dzulkaidah	$f(x)=\frac{x^{(3.7749-1)}e^{-\left(\frac{x}{0.6449}\right)}}{(0.6449)^{3.7749}\Gamma(3.7749)}$	11	November	$f(x)=\frac{x^{(3.6141-1)}e^{-\left(\frac{x}{0.6586}\right)}}{(0.6586)^{3.6141}\Gamma(3.6141)}$
12	Dzulhijjah	$f(x)=\frac{x^{(3.1141-1)}e^{-\left(\frac{x}{0.7810}\right)}}{(0.7810)^{3.1141}\Gamma(3.1223}$	12	December	$f(x)=\frac{x^{(3.3110-1)}e^{-\left(\frac{x}{0.6830}\right)}}{(0.6830)^{3.3110}\Gamma(3.3110)}$

3.6 Determining the Initial Parameter Value of the Weibull Distribution

The parameter value of the Weibull distribution is obtained by using the Newton-Raphson method to approximate the parameter value; because the Newton-Raphson method requires an initial value, then the initial value will be searched by approaching the cumulative function of the Weibull distribution, namely:

$$F(x,\lambda,\gamma)=1-e^{-\lambda x^{\gamma}}$$

$$log\ x=log\frac{1}{\lambda}+\frac{1}{\gamma}log.log\frac{1}{1-Fx}$$

The above equation forms a simple linear regression equation, namely:

$$y=a+bx$$

by using the approximate value of $f(x)=\frac{i-0.5}{n}, i=1,2,\dots,n$, for example:

$$y=log\ x_i$$

$$x=\log\left[log\left(\frac{1}{1-F(x)}\right)\right] \text{ with } a=log\frac{1}{\lambda}$$

$$b=log(log(\frac{1}{1-Fx}))$$

Next, the value a and b will be searched by using the linear regression equation to obtain the initial value, namely:

$$b=\frac{\sum_{i=1}^{n}(x_i-\overline{x})(y_i-\overline{Y})}{\sum_{i=1}^{n}(x_i-\overline{X})^2}=0.18117 \text{ and } a=\overline{y}-b\overline{x}=-0.11261$$

After obtaining the value of the first iteration, the next value can be searched using the same steps as the previous one. If the iteration process is obtained the same value as the previous iteration value, then the iteration process is stopped. Then the initial value generated can be seen in the following table:

Table 4. Initial Parameter Values for the Hijri and AD Years using the Weibull Distribution

Hijri Year	*Weibull*		AD Year	*Weibull*	
	α	β		α	β
Muharram	5.5195	0.8935	January	5.5418	0.8926
Safar	5.6953	0.9066	February	3.8590	0.6027
Rabiul Awal	5.3219	0.8836	March	4.6747	0.8309
Rabiul Akhir	6.0722	0.9223	April	5.1071	0.8655
Jumaidil Awal	5.4528	0.8951	May	6.1337	0.9330
Jumaidil Akhir	5.0305	0.8648	June	6.1321	0.9243
Rajab	5.0417	0.8615	July	4.8433	0.8425
Sya'ban	6.0159	0.9268	August	5.6776	0.8994
Ramadhan	5.5124	0.8908	September	6.0946	0.9320
Syawal	5.8306	0.9063	October	5.4178	0.8858
Dzulkaidah	5.9343	0.9233	November	5.7767	0.9101
Dzulhijjah	6.0763	0.9225	December	5.7139	0.9026

Based on the parameter values in Table 4 above, the Weibull distribution model for the wind speed data for each month of the Hijri and AD years is obtained as follows:

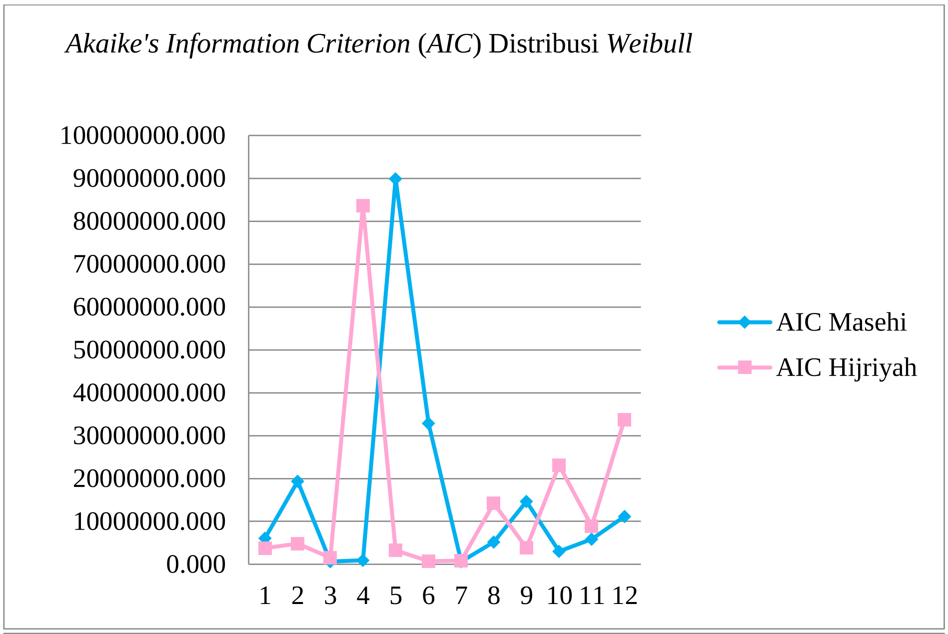
Table 5. Modeling Wind Speed for the Hijri and AD Years using the Weibull Distribution

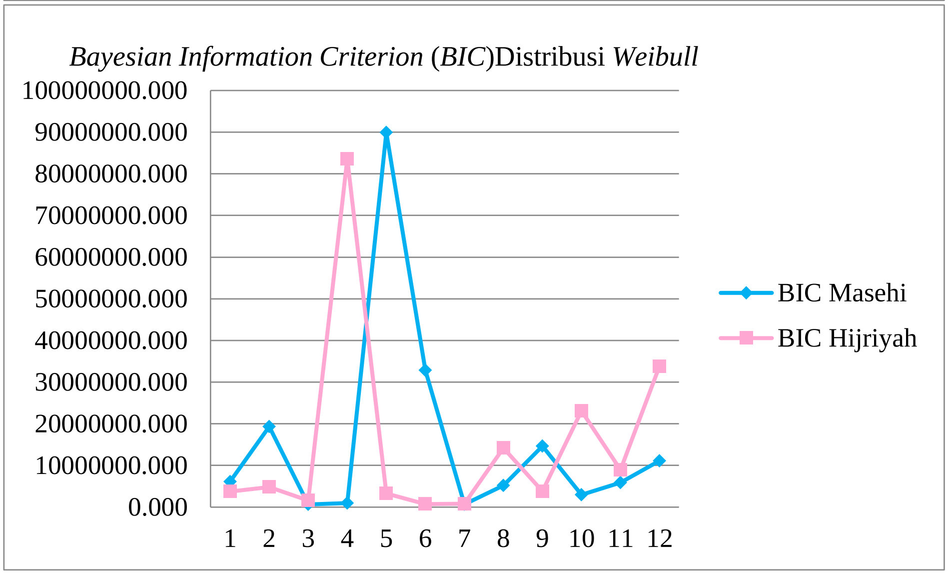
No	Hijri Year	Model	No	AD Year	Model
1	Muharram	$f(x) = \frac{5.5195}{(0.8935)^{5.5195}}(x)^{(5.5195-1)}e^{-\left(\frac{x}{0.8935}\right)^{(5.5195}}$	1	January	$f(x) = \frac{5.5418}{(0.8926)^{5.5418}}x^{(5.5418-1)}e^{-\left(\frac{x}{0.8926}\right)^{5.541}}$
2	Safar	$f(x) = \frac{5.6953}{(0.9066)^{5.6953}}(x)^{(5.6953-1)}e^{-\left(\frac{x}{0.9066}\right)^{(5.6953}}$	2	February	$f(x) = \frac{3.8833}{(0.9207)^{3.8833}}x^{(3.8833-1)}e^{-\left(\frac{x}{0.9207}\right)^{3.883}}$
3	Rabi' al-awwal	$f(x) = \frac{5.3219}{(0.8836)^{5.3219}}(x)^{(5.3219-1)}e^{-\left(\frac{x}{0.8836}\right)^{(5.3219}}$	3	March	$f(x) = \frac{4.6747}{(0.8309)^{4.6747}}x^{(4.6747-1)}e^{-\left(\frac{x}{0.8309}\right)^{4.674}}$
4	Rabi' al-akhir	$f(x) = \frac{6.0722}{(0.9223)^{6.0722}}(x)^{(6.0722-1)}e^{-\left(\frac{x}{0.9223}\right)^{(6.0722}}$	4	April	$f(x) = \frac{5.1071}{(0.8655)^{5.1071}}x^{(5.1071-1)}e^{-\left(\frac{x}{0.8655}\right)^{5.107}}$
5	Jumadil al-awwal	$f(x) = \frac{5.4528}{(0.8951)^{5.4528}}(x)^{(5.4528-1)}e^{-\left(\frac{x}{0.8951}\right)^{(5.4528}}$	5	May	$f(x) = \frac{6.1337}{(0.9330)^{6.1337}}x^{(6.1337-1)}e^{-\left(\frac{x}{0.9330}\right)^{6.133}}$
6	Jumadil al-akhir	$f(x) = \frac{5.0305}{(0.8648)^{5.0305}}(x)^{(5.0305-1)}e^{-\left(\frac{x}{0.8648}\right)^{(5.0305}}$	6	June	$f(x) = \frac{6.1321}{(0.9243)^{6.1321}}x^{(6.1321-1)}e^{-\left(\frac{x}{0.9243}\right)^{6.132}}$
7	Rajab	$f(x) = \frac{5.0417}{(0.8615)^{5.0417}}(x)^{(5.0417-1)}e^{-\left(\frac{x}{0.8615}\right)^{(5.0417}}$	7	July	$f(x) = \frac{4.8433}{(0.8425)^{4.8433}}x^{(4.8433-1)}e^{-\left(\frac{x}{0.8425}\right)^{4.843}}$
8	Sya'ban	$f(x) = \frac{6.0159}{(0.9268)^{6.0159}}(x)^{(6.0159-1)}e^{-\left(\frac{x}{0.9268}\right)^{(6.0159}}$	8	August	$f(x) = \frac{5.6776}{(0.8994)^{5.6776}}x^{(5.6776-1)}e^{-\left(\frac{x}{0.8994}\right)^{5.677}}$

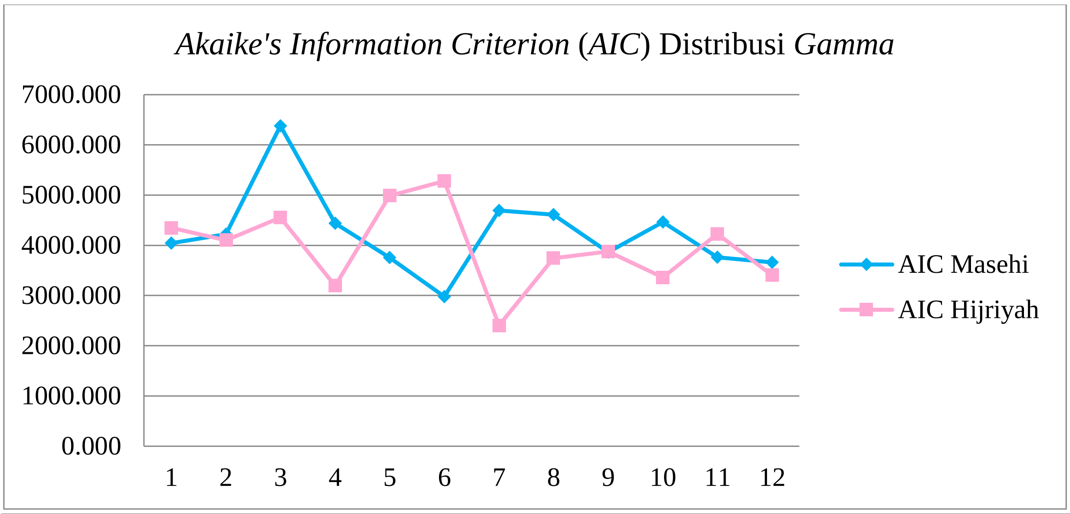
9	Ramadhan	$f(x) = \frac{5.5124}{(0.8908)^{5.5124}}(x)^{(5.5124-1)}e^{-\left(\frac{x}{0.8908}\right)^{(5.5124}}$	9	September	$f(x) = \frac{6.0946}{(0.9320)^{6.0946}}x^{(6.0946-1)}e^{-\left(\frac{x}{0.9320}\right)^{6.094}}$
10	Syawal	$f(x) = \frac{5.8306}{(0.9063)^{5.8306}}x^{(5.8306-1)}e^{-\left(\frac{x}{0.9063}\right)^{5.8306}}$	10	October	$f(x) = \frac{5.4178}{(0.8858)^{5.4178}}x^{(5.4178-1)}e^{-\left(\frac{x}{0.8858}\right)^{5.417}}$
11	Dzulkaidah	$f(x) = \frac{5.9343}{(0.9233)^{5.9343}}x^{(5.9343-1)}e^{-\left(\frac{x}{0.9233}\right)^{5.9343}}$	11	November	$f(x) = \frac{5.7767}{(0.9101)^{5.7767}}x^{(5.7767-1)}e^{-\left(\frac{x}{0.9101}\right)^{5.776}}$
12	Dzulhijjah	$f(x) = \frac{6.0763}{(0.9225)^{6.0763}}x^{(6.0763-1)}e^{-\left(\frac{x}{0.9225}\right)^{6.0763}}$	12	December	$f(x) = \frac{5.7139}{(0.9026)^{5.7139}}x^{(5.7139-1)}e^{-\left(\frac{x}{0.9026}\right)^{5.713}}$

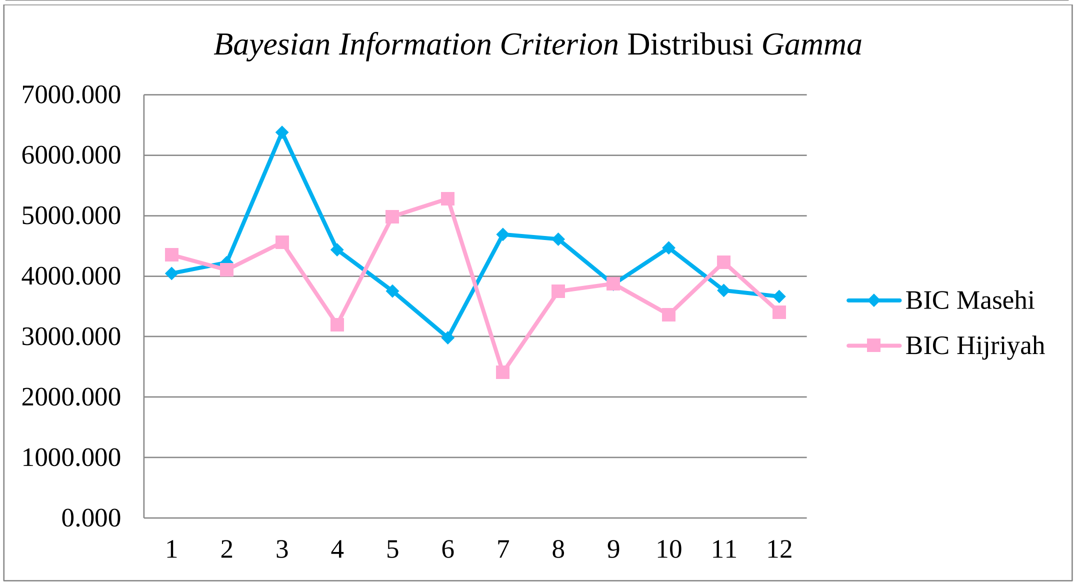
3.7 Goodness of fit

The AIC value for the AD calendar is smaller than the Hijri calendar. Therefore, the wind speed model for the AD calendar is more feasible to use than the Hijri calendar by using the Weibull distribution. The BIC value for the Hijri calendar is smaller than the AD calendar. Therefore, the wind speed model for the Hijri calendar is more feasible to use than the AD calendar by using the Gamma distribution.









Based on Figure 2 above, it can be seen that the BIC value for the Hijri calendar is smaller than the Gregorian calendar. Therefore, the wind speed model for the Hijri calendar is more suitable to use than the Gregorian calendar using the Gamma distribution.

4. DISCUSSION

This study provides an in-depth description of wind speed data in the Gregorian and Hijri years in West Sumatra. Wind speed data collected daily from January 1999 to March 2019 and from Muharram 1420H to Rajab 1440H, show an almost uniform distribution between the two calendars. Descriptive analysis shows that the average wind speed in the Gregorian and Hijri years is the same, which is 2.3 m/s, with standard deviations of 0.56 and 0.53, respectively. The maximum values recorded are 4.0 m/s in the Gregorian year and 3.9 m/s in the Hijri year. Parameter estimation using the Maximum Likelihood method for the Gamma and Weibull distributions shows that both distributions can be used to model wind speed data with different parameters each month. The Gamma distribution shows that the parameters α and β vary between months in the Hijri and Gregorian calendars. For example, in the month of Muharram, the parameters α and β are 3.8114 and 0.6141, while in January they are 3.5021 and 0.6427. For the Weibull distribution, the parameters λ and γ also show significant monthly variations. The initial values of the parameters for the Hijri and Gregorian calendars are determined using the Newton-Raphson method, which ensures accurate parameter estimates for the distribution model. For example, in the month of Muharram, the Weibull parameters are 5.5195 and 0.8935, while in January they are 5.5418 and 0.8926.

Goodness of fit analysis using AIC and BIC indicates that the Weibull distribution model is more appropriate for wind speed data in the Gregorian calendar, while the Gamma distribution is more appropriate for the Hijri calendar. This shows that although wind speed data have almost similar characteristics, the most appropriate model for predicting wind speed can vary depending on the calendar used. Overall, this study highlights the importance of selecting an appropriate distribution model in wind speed data analysis. The results of this study not only provide new insights into wind speed behavior in West Sumatra, but also offer a methodological approach that can be applied to similar studies in other regions. In the future, this study can be expanded by considering other factors that affect wind speed, such as geographical conditions and extreme weather, to improve the accuracy of the predictive model.

5. CONCLUSIONS

Based on the results of the AIC and BIC tests, it can be concluded that the Hijri calendar model on the Gamma distribution is more suitable for wind speed data in West Sumatra than the Weibull distribution. This is indicated by the AIC and BIC values obtained from the Gamma distribution smaller than the Weibull distribution.

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