Statistical Analysis of Wind Speed for Energy Potential estimation in Bahir Dar, Ethiopia using Weibull

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Abstract

In this study, statistical analysis method has been used to assess the wind energy potential in Bahir Dar, Ethiopia. The analysis is conducted based on the wind speed data collected by National Meteorological Agency (NMA) for the time span of 2006 to 2015. Weibull distribution function has been used as a statistical analysis model to fit the actual data via probability density function and cumulative density function. While estimating the Weibull parameters (shape and scale) in this wind energy potential assessment, three statistical methods, namely, the Graphical method (GM), method of moments (MOM) and standard deviation method (STDM) were used. Comparison of these statistical methods for the good fit was done by the analysis of the relative percentage error (RPE), root mean square deviation (RMSD), mean percentage error (MPE) and coefficient of variance (R^2) procedures. The regression coefficient (R^2) between the actual wind speeds and the Weibull predicted values ranged between 0.614-0.872. From this result, the method of moment (MOM) is the best efficient method for determining the value of shape and scale to fit the Weibull distribution curves. The annual mean wind speed in Bahir Dar is 6.864m/s, while the mean wind speed and the power density predicted by the Weibull probability density function are 5.964m/s and 11.373kwatt/m^2 respectively. The Weibull distribution function can be used with acceptable accuracy for prediction of wind energy output required for preliminary design and assessment of wind power plants.

Keywords: T Weibull distribution function, Probability density function, Cumulative density function.

Resumen

D En este estudio, se utilizó un método de análisis estadístico para evaluar el potencial de la energía eólica en Bahir Dar, Etiopía. El análisis se lleva a cabo en función de los datos de velocidad del viento recopilados por la Agencia Meteorológica Nacional (NMA) durante el período de 2006 a 2015. La función de distribución de Weibull se ha utilizado como modelo de análisis estadístico para ajustar los datos reales a través de la función de densidad de probabilidad y la densidad acumulada. función. Al estimar los parámetros de Weibull (forma y escala) en esta evaluación del potencial de energía eólica, se utilizaron tres métodos estadísticos, a saber, el método gráfico (GM), el método de momentos (MOM) y el método de desviación estándar (STDM). La comparación de estos métodos estadísticos para el buen ajuste se realizó mediante el análisis de los procedimientos de error porcentual relativo (RPE), desviación cuadrática media (RMSD), error porcentual medio (MPE) y coeficiente de varianza (R2). El coeficiente de regresión (R2) entre las velocidades reales del viento y los valores previstos por Weibull osciló entre 0,614 y 0,872. A partir de este resultado, el método del momento (MOM) es el mejor método eficiente para determinar el valor de la forma y la escala para ajustarse a las curvas de distribución de Weibull. La velocidad media anual del viento en Bahir Dar es de 6,864 m/s, mientras que la velocidad media del viento y la densidad de potencia previstas por la función de densidad de probabilidad de Weibull son 5,964 m/s y 11,373 kvatios/m2, respectivamente. La función de distribución de Weibull se puede utilizar con una precisión aceptable para la predicción de la producción de energía eólica requerida para el diseño preliminar y la evaluación de las plantas de energía eólica.

Palabras clave: T Función de distribución de Weibull, función de densidad de probabilidad, función de densidad acumulativa.

I. INTRODUCTION

Wind energy is a non-depletable, site dependent, non-polluting and potential source of alternative energy. Nowadays, both developed and developing countries are becoming increasingly more interested in using pollution free, cost effective and renewable sources of energy like wind power [1, 2]. The primary energy consumption in Ethiopia is covered largely by biomass and imported fossil fuels. The country's reliability of electricity supply varies widely across the nation [3]. As is well known, Ethiopia is endowed with different renewable energy resources such as, hydro, wind, solar, geothermal and bio-energy. Wind power is the fastest growing technology in the whole world and wind energy is in general applicable for both power generation and water pumping applications for rural societies [4]. Wind power is replenished daily by the sun, due to the uneven heating of the Earth's surface. Furthermore, wind is accelerated by major land forms, so that entire regions may be very windy while others are relatively calm. Wind is highly variable, both in space and in time [5]. A feasibility study of any wind energy project should certainly include a study of the spatial, temporal and directional variations of wind velocity. On the other hand, accurate knowledge about the wind characteristics is needed for planning, design and operation of wind turbines [6, 7]. This is a very difficult task because of the extreme transitions in the speed and direction of wind at most sites. In order to optimize wind energy conversion systems and to maximize the energy extraction, annually, monthly, daily, hourly and even by minute frequency distributions of wind data are required.

In the last few years, increasing attention has been given to analysis the wind speed with distribution statistics in wind engineering and wind energy industries. Knowledge of the wind Characteristics and variability in the lower few hundred meters of the atmosphere is important for exploitation of wind energy [8]. To investigate the feasibility of the wind energy resource at any site, there are basically two methods or ways. The first method which deals with calculating wind power potential is based on measured values that are recorded at meteorological stations. On the other hand, the second method employs probability distribution functions, namely the Rayleigh distribution, Normal distribution, Binomial distribution, Poisson distribution and Weibull distribution.

For more than half a century, the Weibull distribution has attracted the attention of statisticians working on theory and methods as well as various fields of statistics [9]. Even though, many research papers have been published on Weibull distribution, the research is still going on worldwide with Weibull distribution for wind energy estimation and Weibull distribution to find the most reliable methods for wind energy estimation. Together with the Gamble, Ralyeigh and Normal distributions, the Weibull distribution is the most popular model for wind speed statistical analysis [9, 10]. In order to precisely determine the values of the Weibull parameters (shape and scale), different scientists and engineers have developed different methods for wind energy assessment [11, 12]. Recently, Mohammadi and Mostafaeipour [13] used two methods, standard deviation method (STDM) and power density method PDM) for wind data assessment in Zarrineh, Iran. Seguro and Lambert [14] also concluded that the maximum likelihood method (MLM) performs better than the popularly used graphical method (GM) and method of moments (MOM).

Therefore, the main purpose of the current study is to analyze the wind energy resource potential at Bahir Dar using the Weibull distribution function. In this analysis the Weibull parameters were determined by employing the three statistical methods mentioned in the literature [11, 12, 13, 14], graphical method (GM), standard deviation method (STDM) and method of moments (MOM). Comparison of these methods in modeling the actual wind speed data with Weibull distribution function were analyzed by different inaccuracy analysis procedures.

II. METHODOLOGY

The wind speed data used in this study was obtained from National Meteorological Agency located at Bahir Dar, which is the capital city of the Amhara National Regional State. The data used in this study is a long time series data, that is, in the time span of 2006 to 2015. The geographic location of the site is 11.59ºN Latitude and 37.88ºE Longitude and is located at 1800m altitude above sea level. The mean monthly wind speed data obtained from the local meteorological station was measured at a height of 2m using cup-anemometer and for standard statistical analysis purpose the data was extrapolated to a height of 10m using equation (1) below [15, 16],

$$\frac{v}{v_o} = \left(\frac{h}{h_o}\right)^{\alpha}, \qquad (1)$$

where, v is the wind speed at the hub height(h), v_o is wind speed at the original height (h_o) and α is the surface roughness coefficient, which can be determined using equation (2) below,

$$\alpha = \frac{(0.87 - 0.88 \ln v_o)}{(1 - 0.88 \ln(\frac{h_o}{v_o}))}. \qquad (2)$$

In order to calculate the power output from a given wind turbine, it is indispensable to know the wind speed distribution at the planned turbine location. It is very easy to find the mean wind speed at a certain location, but this is not sufficient for the available regional wind energy potential estimation. This is due to the fact that, the power potential of the wind is related to the cube of the wind speed. The proper wind resource assessment is a standard and important component of the wind energy project developments. For the wind industry, it is very important to be able to describe the variation of wind speeds. The turbine designers need such information to optimize the design of their turbines and to evaluate their income from the electricity generation. Therefore, information from the statistical analysis helps to determine the probability distribution of the appearance of several wind speed values in the course of time [17]. The wind speed probability distributions are the main tools, used in the wind related investigations and project calculations.

Their mathematical functions propose a wide range of techniques, utilized to identify the parameters of the distribution functions [18, 19]. The employment of such functions for analyzing the wind speed data and wind energy economics is verified very carefully [20]. The wind speed analysis is mostly modeled by applying the Weibull distribution [17]. This statistical tool tells us how often winds of different speeds will be seen at a location with a certain average (mean) wind speed.

In this study, the authors used only the Weibull distribution function for wind power assessment at Bahir Dar, Ethiopia based on a period of ten years (from 2006 to 2015) metrological wind speed data. The practice and investigations show that, the Weibull probability distribution function should be found to fit the frequency distribution of wind speed measurements very accurately. This means that, most of the wind speed distribution characteristics at any site can be described by two parameters [21, 22, 23]. Nowadays, numerous statistical models have been developed and used for analyzing wind speeds and for assessing energy potential at any location [24, 25]. Among these methods, Weibull probability distribution function is one of the most appropriate, conventional and suggested method for wind speed analysis owing to a better fit for measured probability density distributions than the other statistical functions [21].

A. Weibull Distribution Function

The Weibull density function is a two-parameter function characterized by a dimensionless shape parameter (k) and Weibull scale parameter (c in m/s). According to Junyi [19], the two-parameter Weibull probability distribution function has proven to be the most appropriate, accepted and recommended distribution function for wind speed data analysis. The variation in wind speed is characterized by two distribution functions: probability density function and the cumulative distribution function.

B. Weibull Probability Density Function

The Weibull probability density function ($f(v)_{WB}$) indicates the probability of wind at a given wind speed and is defined as [20, 26],

$$f(v)_{WB} = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} \exp\left(-\left(\frac{v}{c}\right)^{k}\right). \qquad (3)$$

The scale parameter can be related to the mean wind speed ($\bar{v}$) through the shape parameter, which determines the consistency of wind speed at a given location.

C. Weibull Cumulative Distribution Function

The Weibull cumulative distribution function ($F(v)_{WB}$) gives the probability that wind speed is equal to or lower than v, or within a given wind speed range. The Weibull cumulative distribution is the integral part of the probability density function and is expressed as [26, 27],

$$F(v)_{WB} = 1 - \exp\left(-\left(\frac{v}{c}\right)^{k}\right). \qquad (4)$$

All these distributions are used to determine the probability of occurrence. The nature of the occurrence affects the shape of the probability curve and in the case of the wind regime, the cumulative curve probability nature mostly fits to the Weibull function. Several methods to estimate Weibull parameters are found in the literature [26]. Some of these methods used in this study are, Graphical method (GM), Method of moments (MOM) and Standard deviation method (STDM).

Graphical method is implemented by plotting a graph in such a way that, the cumulative Weibull distribution becomes a straight line, with the shape factor (k) as its slope [28]. Taking the logarithm of both sides of equation (4) gives,

$$\ln[-\ln(1 - F(v)_{WB})] = k \ln v - k \ln c\,. \qquad (5)$$

Equation (5) is a linear equation and can be fitted using the following least square regression method: $y = ax + b$, for $y = ln\,[-ln\,(1 - F(v)_{WB})]$, $x = ln\,(v)$, $a = k$ and $b = -kln\,(c)$. The cumulative distribution function can be estimated easily, using an estimator, which is the median rank [26] as,

$$F(v)_{WB} = \frac{i - 0.3}{N + 0.4}\,, \qquad (6)$$

where, i is the number of the wind speed measurements and N is the total number of observations [29]. The relationship between $ln(v)$ against $ln\,[-ln\,(1 - F(v)_{WB})]$ represents a straight line with slope k and the intersection point with Weibull line gives the value of the Weibull scale parameter (c).

D. Method of Moments (MOM)

Method of moment is another method commonly used in the field of parameter estimation [26]. It is based on the numerical computation of mean wind speed and standard deviations of wind speeds given by,

$$\frac{\sigma}{\bar{v}} = \sqrt{\frac{\Gamma(1+\frac{2}{k})}{(\Gamma\left(1+\frac{1}{k}\right))^2 - 1}}\,, \qquad (7)$$

where, $\bar{v} = \frac{1}{n}\sum_{i=1}^{n} v_i$ and $\rho = [\frac{1}{n-1}\sum_{i=1}^{n}(v_i - \bar{v})^2]^{1/2} = c[\Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2(1 + \frac{1}{k})]^{1/2}$

The dimensionless shape parameter and Weibull scale parameters can be calculated as,

$$k = \left(\frac{0.9874}{\frac{\sigma}{\bar{v}}}\right)^{1.0983}\,, \qquad (8)$$

$$c = \bar{v}\,\Gamma\left(1 + \frac{1}{k}\right), \qquad (9)$$

where, Γ is the Gamma function. The average wind speed can be expressed as a function of Weibull scale parameter (c) and dimensionless Weibull shape parameter (k) derived from the Gamma function given by,

$$\Gamma = \int_0^{\infty} y^{x-1} \exp(y)\, dy, \qquad (10)$$

where, $y = (\frac{v}{c})^k$ and $\frac{v}{c} = y^{x-1}$ with $x = 1 + \frac{1}{k}$.

After some manipulations, we get,

$$\bar{v} = c + \Gamma\left(1 + \frac{1}{k}\right) = 0.8525 + 0.0135k + \exp(-[2 + 3(k-1)])$$

E. Standard Deviation Method (STDM)

Standard deviation method is constructive where only the two parameters such as mean wind speed and standard deviations are available [27]. It is well known as empirical method and could be considered as a unique case of method of moment, from which Weibull shape and scale parameters are estimated by,

$$k = (\frac{\sigma}{\bar{v}})^{-1.086} \text{ and } c = v\Gamma(1+\frac{1}{k}) . \quad (11)$$

Alternatively, Weibull scale parameter can be projected from the expression given by,

$$c = \frac{\bar{v}k^{2.6674}}{0.184+0.816k^{2.73855}} . \quad (12)$$

F. Statistical Inaccuracy Analysis

To investigate the best method for analysis, some statistical inaccuracy analysis tools were used by previous researchers [17, 25, 26] to analyze the efficiency of the above – mentioned methods. In this study the following inaccuracy analysis tests were used.

(a) Relative percentage error (RPE)

$$RPE = \frac{v_{i,w}-v_{i,m}}{v_{i,m}} \times 100\%.$$

(b) Root - mean square deviation (RMSD)

$$RMSD = [\frac{1}{N}\sum_{i=1}^{n}\left(v_{i,m} - v_{i,w}\right)^2]^{1/2} .$$

(c) Mean percentage error (MPE)

$$MPE = \frac{1}{N}\sum_{i=1}^{n}\left(\frac{v_{i,w}-v_{i,m}}{v_{i,m}}\right) \times 100\%.$$

(d) Analysis of variance or regression coefficient

$$R^2 = \frac{\sum_{i=1}^{n}\left(v_{i,m}-v_{i,\bar{v}}\right)^2 - \sum_{i=1}^{n}\left(v_{i,m}-v_{i,w}\right)^2}{\sum_{i=1}^{n}\left(v_{i,m}-v_{i,\bar{v}}\right)^2}.$$

where, N is the number of wind speed observations, $v_{i,m}$ is the frequency of observation or ith calculated value from measured data, $v_{i,w}$ is the frequency of Weibull or ith calculated value from the Weibull distribution, $v_{i,\bar{v}}$ is the mean of ith calculated value from measured data.

In general, the relative percentage error shows the percentage deviation of the calculated values from the Weibull distribution and the calculated values from measured data. Similarly, the mean percentage error shows average of percentage deviation of the calculated values from the Weibull distribution and the calculated values from measured data. Best results are obtained when these values are close to zero. Regression coefficient (R^2) determines the linear relationship between the calculated values from the Weibull distribution and measured data. The ideal value of regression coefficient is equal to one. It is used in testing the efficiency of the method.

G. Coefficient of Variation (COV)

Coefficient of variation is defined as the ratio of mean standard deviation to the mean wind speed expressed in terms of percentage. It demonstrates the uncertainty of wind speed and can be expressed as [10, 30, 31],

$$COV(\%) = \frac{\rho}{\bar{v}} \times 100\% .$$

H. Wind Energy Potential

Wind turbine is a structure that transforms the kinetic energy of the incoming air stream into electrical energy. The performance of a wind turbine is primarily characterized by the manner in which the main indicator of power varies with wind speed. In general, the electrical power output of a model wind turbine commonly relies on cut-in, rated and cut-off wind speeds. Accurate models of power curve serve as an important tool in wind power forecasting [26, 30, 31]. The theoretical wind energy per unit area for a given time period (t) in second based on the Weibull distribution function parameters is given by,

$$E_W = {}^1/_2\, \rho\, c^3 \Gamma\left(1+\frac{3}{k}\right) t . \quad (13)$$

Similarly, the theoretical wind power density based on the Weibull distribution function parameters is given by,

$$P_W = {}^1/_2\, \rho\, c^3 \Gamma\left(1+\frac{3}{k}\right). \quad (14)$$

The analogous energy based on actual time-series data can be obtained using the relation given by,

$$P_A = {}^1/_2\, \rho\, \bar{v}^3 . \quad (15)$$

where, $\bar{v}^3$ is the mean of wind speed cube. ρ is the air density and for standard conditions (i.e., at sea level with temperature of 15ºC and pressure of 1 atmosphere) is equal to 1.225kg/m^3. Since the Weibull shape parameter (k) varies with height, in the current study, the authors used the Weibull parameters to find wind speed distribution and wind power density (wind energy potential) in the site at a height of 10 m.

III. RESULT AND DISCUSSION

In this statistical analysis, an effort is made to assess the wind power density potential in the site by using Weibull distribution function and three statistical methods to estimate the Weibull parameters. The most important results of the analysis are presented based on tables and figures.

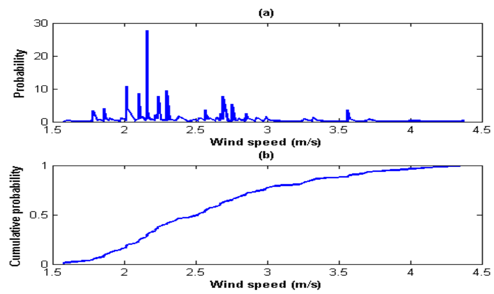

FIGURE 1. (a) Monthly mean wind speed for each year, (b) Yearly mean wind speed for each year at Bahir Dar based on ten years (2006 - 2015) wind speed data at height of 10m.

As can be seen in figure 1(a), in the study area, the maximum monthly mean wind speed has been observed during the warm period of a year, that is, in the months of April & May, with a mean wind speed of 3.506 m/s. On the contrary, during the Ethiopian rainfall period of the months from August to September, the minimum mean wind speed was observed throughout the collected ten years data with the exception of 2015. As can be observed from figure 1(b), the mean wind speed decreases over years from 2006 to 2009 and remains steady for the years from 2010 to 2012 and then decreases slightly again in 2013 & 2014. This variation in local mean wind speed leads to further studies by considering some possible factors.

TABLE I. Characteristic: Mean speed (v), standard deviation (sigma), Weibull parameters (k & c) from STDM, power densities (P_W Weibull & P_A actual) and coefficient of variation (COV) in each year for the period of ten years.

year →	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
$\bar{v}$(m/s)	3.134	3.003	2.858	2.482	2.562	2.449	2.537	2.294	2.081	2.515
ρ (m/s)	0.529	0.573	0.510	0.981	0.653	0.394	0.493	0.478	0.308	0.897
k	6.898	6.041	6.493	2.740	4.412	7.270	5.925	5.488	7.977	3.065
c(m/s)	3.344	3.233	3.061	2.791	2.814	2.603	2.735	2.485	2.198	2.816
P_W(w/m^2)	16.552	14.175	12.44	8.718	6.549	7.928	8.494	6.043	4.894	2.721
P_A(w/m^2)	18.858	16.584	14.295	12.047	10.297	8.989	10.005	7.393	5.521	9.744
COV (%)	17.645	19.938	18.642	24.575	26.618	16.794	20.297	21.778	15.456	37.228

Table I yields some basic information about the site wind speed variability based on monthly mean as well as annual mean wind speed, standard deviation, power density, Weibull parameters (k & c) and COV at a height of 10m. Assessment of the wind energy potential at a particular site or area involves analyzing the wind characteristics as presented in table 1. The distribution of the measured wind speed, the maximum wind speed, the variability (seasonality & diurnal) of the wind speeds are characterized based on these parameters. Wind characteristics were studied by using cumulative frequencies of the observed wind velocities and the Weibull probability distribution.

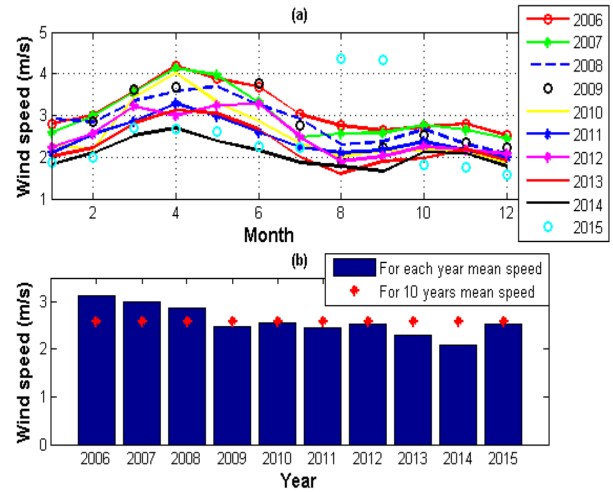

FIGURE 2: (a) Probability density variations and (b) cumulative probability density variations of wind speed for a period of ten years.

The frequency probability distribution showing the monthly variation in wind speed from 2006 to 2015 is shown in figure 2(a) and it also indicates that cumulative frequency probability which is used for finding the shape and scale parameters of the Webull distribution function. The whole year cumulative distributions of the wind speeds from 2006 to 2015 are depicted in figure 2(b). The probability distributions and the cumulative distributions showing the annual wind speed distribution are illustrated in figures 2(a) and 2(b) respectively. These figures show an increase in the probability of observing higher wind speeds from 2006 to 2015.

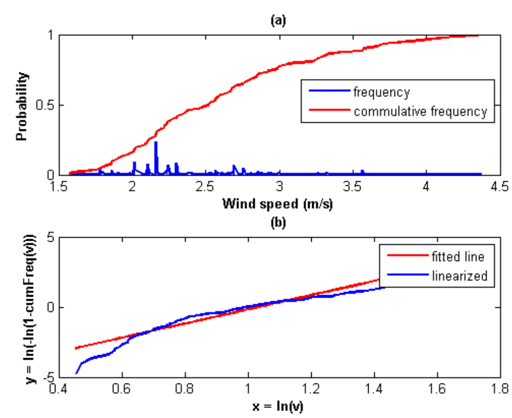

FIGURE 3: (a) Probability and cumulative probability variations of actual wind speed time series data and, (b) The linearized curve and its fitted line in determining the two Weibull parameters using GM.

The annual probability density frequency and cumulative frequency distributions of actual wind speed for the location obtained are shown in figure 3. The probability density function is used to illustrate the fraction of time for which a given wind speed possibly prevails at a location. As expected, the peak of the density function frequency of the site is towards the higher values of mean wind speed (figure 3). It should be remarked that, the peak of the probability density function curve indicates the most frequent speed. It can be observed from figure 3(a) that, the most frequent wind speed expected in Bahir Dar is 2.173m/s whereas in this actual frequency distribution analysis, the mean wind speed in the location under consideration is 2.6132 m/s.

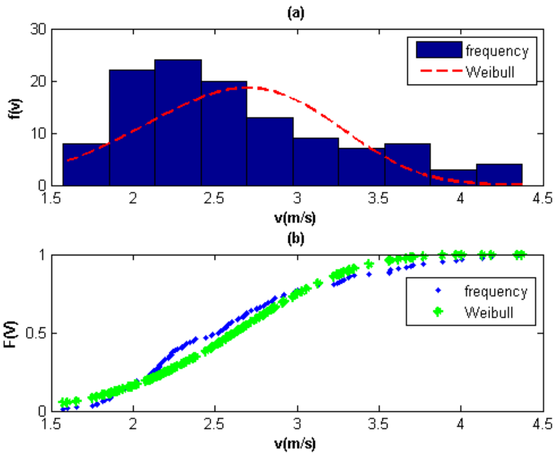

FIGURE 4. (a) Comparison of the Weibull probability density function with actual frequency probability, (b) Comparison of the Weibull cumulative probability density function with actual cumulative frequency probability, where GM is used for Weibull parameters estimation.

The probability density distribution and cumulative probability distributions of wind speed at Bahir Dar from Weibull statistical analysis and also from actual time series data have been shown in figure 4. The cumulative distribution function can be used for estimating the time for which wind speed is within a certain speed interval. For wind speeds greater or equal to 2m/s shall be considered as a cut-in wind speed at Bahir Dar, which has frequencies of about 83%. As observed from Adama wind farm, in Ethiopia, the wind turbines system used in the wind farm are designed with a cut-in wind speed of 3m/s at a height of 70m for electricity generation.

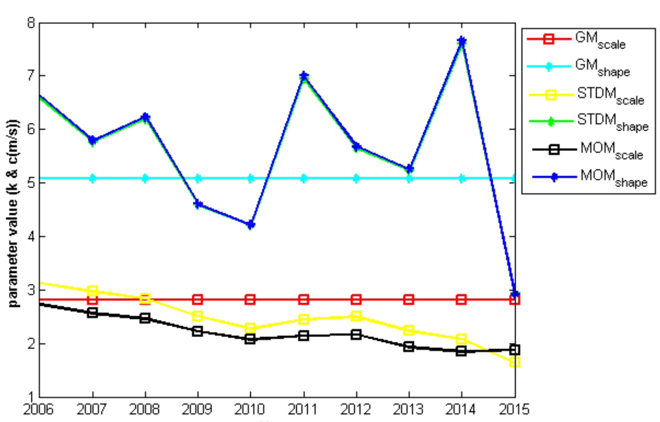

FIGURE 5. Weibull scale and shape parameters designed by the three statistical approaches at Bahir Dar for a period of ten years wind speed data.

Figure 5 shows the yearly variations of Weibull distributions generated by three statistical methods considered for estimating Weibull shape and scale parameters at the site. It can be seen that, the divergence for shape parameters became more significant than that of scale parameters. The divergence of the dimensionless Weibull shape parameters (k) is observed to be less significant in the case of MOM as compared to GM and STDM. The consistency range is observed at Weibull scale parameters in GM, MOM and STDM results. To analyze the performance of the three statistical methods described in estimating Weibull parameters, a model of cross verification has been summarized and shown in table II.

TABLE II. Performance of the three statistical methods used to estimate the Weibull distribution function parameters for wind speed data at a height of 10m.

Statistical Methods	k	c(m/s)	RPE (%)	$RMSD$	MPE (%)	R^2
GM	5.082	2.818	59.63	0.00091	0.505	0.614
STDM	5.568	2.460	34.18	0.00090	0.289	0.798
MOM	5.601	2.197	19.17	0.00094	0.162	0.871

Three statistical methods performance and efficiency evaluation are done by considering minimum error and maximum efficiency, and the results shown in table 2 indicate that, MOM is more efficient method as compared to the other methods.

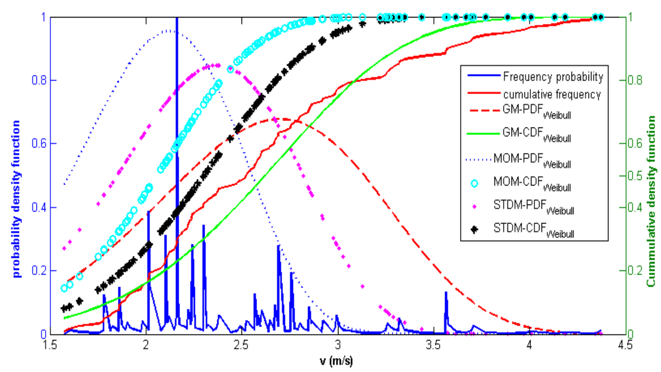

FIGURE 6. Comparison of the Weibull probability density function and cumulative density function obtained within the three methods of parameter determinants and actual time series data.

Since wind speed data is soundly characterized by both Weibull probability density function (PDF) and cumulative distribution function (CDF), the Weibull parameters estimated by the three statistical methods are compared.

From the results shown in figure 6, the Weibull probability density function of MOM shows that, the mean speed is almost equivalent to that of the speed which has a maximum frequency of occurrence in the time series data. In addition, when the Weibull parameters compared in these distributions of the three statistical methods, shape parameter value is higher in MOM and smaller in GM whereas scale parameter value is smaller in MOM and higher in GM. The value of the Weibull parameters obtained from STDM is between GM and MOM.

IV. CONCLUSION

In this work, statistical analysis method has been used to assess the wind energy potential in Bahir Dar based on the wind speed data collected by NMA in the time span of 2006 to 2015. The statistical diagnosis of the best Weibull distribution method for the wind speed data analysis is presented. By using the available wind speed data, the values of shape parameter (k) and scale parameter (c) are determined using three methods and are then investigated as to how efficiently the methods have estimated the Weibull parameters with minimum error. The results of our finding show that, MOM is the most efficient method for determining the value of k and c to fit the Weibull distribution curves as compared to the other three statistical methods. Methods such as STDM and GM are less efficient methods to fit the Weibull distribution curves for the assessment of wind speed data. MOM has shown better results than STDM to fit the Weibull distribution curves. The value of shape factor, scale factor, wind speed and power were determined at a height of 10m using extrapolation of numerical equations to satisfy the wind power classes as discussed in this paper. The poor class wind power density has been found in this site since its mean value is less than $100W/m^2$. The current study offers a new pathway on how to evaluate feasible locations for wind energy assessment which is applicable at any windy sites in any country in the world.

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