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Prospect of Wind Electricity Generation in Kutubdia Island, Bangladesh

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ABSTRACT

Kutubdia is an isolated island and normally the power demand partially fulfilled by diesel generators in this remote island. It is very expensive, difficult, highly risky and time-consuming to transport diesel to this isolated island. Another alternative source of power is1MW wind battery hydride power plant. This paper presents the current power situation and a statistical analysis of wind power potential in Kutubdia for extension of wind power plant to meet the power demand there. For the analysis, the wind data from 2000 to 2006 have been collected from the meteorological department, Bangladesh. The data has been sorted in the appropriate frequency like daily, monthly and annual mean wind speed and analysis of two important parameters like Weibull's shape factor (k) and scale factor (c) by three methods like Weibull's paper method, Standard deviation method and energy pattern factor method. It has been found that the value of k remains in between 1.4 to 3.38 and that of c remains between 2.83 to 6.90. The most of the Weibull functions follow very close to the Raleigh function (k=2) for the selected sites. The Weibull's probability density function f(v) and Weibull's function F(v) have been plotted and analyzed with 2006 wind data only and noted its remarkable variations.

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From the analysis, it has been clear that the mean wind speed is above 5.5 m/s in each month. So, Kutubdia Island has more prospect of wind power for electricity generation. To meet the power demand, it has been recommended that the extension wind power project is needed to fulfill the total power demand and develop the people.

Keywords: *Wind Energy, Light House, Weibull's Distributions, Wind Turbine, Surface Roughness.*

1 INTRODUCTION

Energy which is non-polluting, cost effective and available in the world is called renewable energy. In the world, the utilization of energy is increasing gradually day by day. Most of the energies come from the non-renewable sources like natural gas, fossil fuel, and coil etc and it will be finished after some days. But the world needs more and more energy which never be finished and minimum environmental impact. Only renewable energy can fulfill the conditions and it will be the next and friendly environmental energy sources in the world. There are different types of renewable energy is available around the world like solar energy, wind energy, tidal energy, geothermal energy etc but mostly used and cost effective energy sources is solar and wind. Like other developing countries Bangladesh has its initial stage to use renewable energy. Solar is most popular in Bangladesh and it already used in both lighting and irrigation. Due to the crises of diesel fuel in dry season, solar has been used for pumping water in some districts of Bangladesh. The Bangladesh govt. has encouraging peoples to use solar energy and take steps to setup solar panel in every distribution sub-station. But in solar per unit energy generation cost is more than wind. Recently, the utilization of wind power is increasing in many developed, as well as, under developed countries. Although the wind speed may vary from one location to another location. About twenty years ago, large numbers of experiments were done in the laboratory to develop the appropriate technology for utilization of wind energy. It was quite cost competitive with any thermal and coal power plants. Now a day, wind energy conversion systems (WECS) [40] have been extensively used in Germany, Denmark, Netherlands, UK, Russia, Brazil and Australia. Asian counties, like China, India and Indonesia have also been using this technology [54]. The wind resource assessments have been completed recently in Japan, Thailand, Srilanka and Malaysia. A few wind

farms have been installed in Japan, Thailand and Srilanka. Malaysia is also going to install wind farms in wind prospective areas. Compared to other developing countries, Bangladesh is in its initial stage for utilizing WECS. So, like other developing countries Bangladesh needs more research on wind for power generation.

2 GEOGRAPHICAL AND WINDY LOCATION OF KUTUBDIA ISLAND

Bangladesh is one of the most populated countries in the world having 32% coastal area that is 47,211 square kilometrs. Kutubdia is one of the coastal islands in Bangladesh which is shown in **Fig.1**. It is situated in cox's bazar district (21°54.71′ North Latitude 91°52.43′ East Longitude) with an area of 27 sq km which was 54 sq km., Distance of Thana/Upozila from Zila sadar by road 90 km, is bounded by the bay of bengal on the north, west and south, Kutubdia channel, Banshkhali, Chakaria and Maheshkhali Upazilas on the east. It consists of 6 union parishads, 9 mouzas and 29 villages with a thriving population of approximately 1,14,000; male 51.66%, female 48.34%. The main occupations are agriculture related 32.13% and fishing related 4.67%.

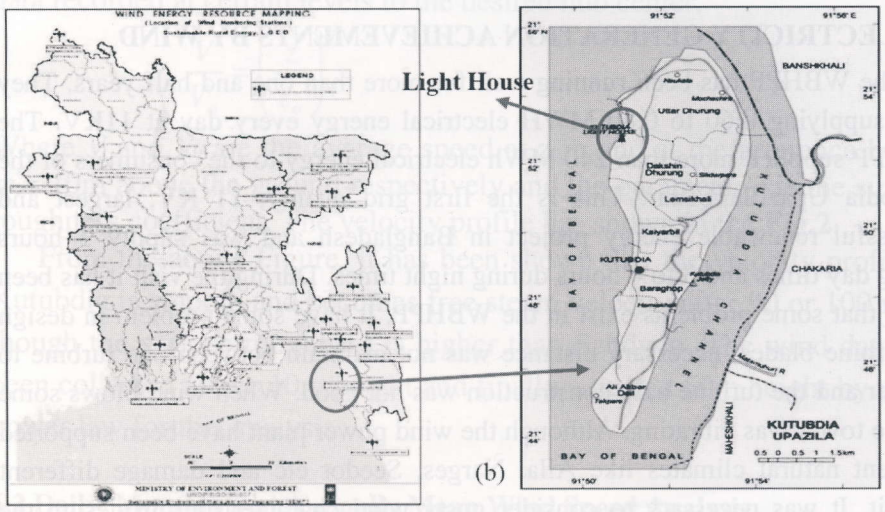


Figure 1: (a) Bangladesh map showing the location of wind speed monitoring stations, (b) Kutubdia Island showing the position of light house (1MW capacity wind Battery Hydride power plant).

3 PRESENT POWER SITUATION OF THE ISLAND

The author himself and his supervisor Dr. Mahabubul Alam, Professor and head of the Mechanical Engineering department, Bangladesh University of Engineering and Technology and Engr. Md. Murtuza, dept. of sustainable rural energy (SRE), Local Government Engineering Department (LGED) has been visited the island to observe the present power situation and the existing wind power project in Kutubdia. The aim of the visit was to observe the running project, feasibility study, problems and the local people reactions etc. The outcomes of the visit have given in this present research.

Kutubdia is an isolated island. Normally, electricity is generated by diesel generators in this remote island. There is a 250 KW diesel power station in this island. It is very expensive, difficult, highly risky and time consuming to transport diesel to this isolated island. Some people used solar panel in their house. Another alternative source of power of the island is 1 MW capacity Wind Battery Hybrid Power Project. It have been replacing directly diesel with the energy generated by the wind. When the WBHPP supply electricity at 11KV levels, the diesel generators are stopped completely. This Island has no industry or factories but have some office and market in Kutubdia Upazilla Sadar. So, most of the people's needs power only for lighting and fan at night time. Only 50% of the total people are beneficial for the power.

4 ELECTRICITY GENERATION ACHIEVEMENTS BY WIND

The WBHPP has been running well for more than one and half years. They were supplying 0.60 to 0.80 MWH electrical energy every day at 11KV. The WBHPP supplied more than 240 MWh electrical energy to the consumers of the Kutubdia Upazilla Sadar. This is the first grid quality, 11 KV, largest and successful renewable energy project in Bangladesh and was supply 3 hours during day times and 3 to 4 hours during night times. During the visit it has been found that some problems exist in the WBHPP. It have some problem in design the turbine blades, necessary distance was not maintain between one turbine to another and the turbine base construction was not good. When wind blows some turbine tower was vibrating. Although the wind power plant have been supported different natural climates like Aila, Narges, Seedor etc and damage different parts it. It was necessary to consider gusty wind characteristics in design the plant. Another demerit of the plant is 1000 pcs 12 V DC rechargeable batteries. The plant is unable to supply power without charge of its battery though wind velocity is available.

5 CUSTOMERS REACTIONS ABOUT POWER

The visiting team also taken in consideration the customer's reactions both they were got the facilities electricity from wind and unaffiliated people. The facilitate people gives different massage about the power but everyone told that "the voltage and power of the electricity from the wind was very good than existing diesel generator and they got more light from the wind power". The team also concern with Kutubdia diesel power plant, under Bangladesh Power Development Board (BPDB). They also told us that the wind power supplied up to 240 KW power continuous 5-6 hours per day. When wind power plant supply the power then the diesel power plant was shut down.

6 WIND DATA ANALYSIS FOR EXTENSION OF WIND POWER PLANT

6.1 Data Collection & Adjustment

The data has been collected from Bangladesh Meteorological Department for both islands Sandwip and Kutubdia from 2000 to 2006. In this six years, the wind data has been collected at the starting to the end of the year from those island. The wind speed changes with height, so it is necessary to know the wind speed at wind turbine hub height. The wind power law has been recognized as a useful tool to transfer the anemometer data recorded at certain levels to the desired hub center.

$$\frac{V}{V_o} = \left(\frac{z}{z_o}\right)^{\eta} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where V and V_0 are the average speed at z m and at the reference height z_0 = 10m above the ground respectively and the parameter η is the surface roughness coefficient. The velocity profile has shown in the **Fig.2**.

From the above Figure, it has been shown that the velocity profile in Kutubdia is smooth and becomes free steam velocity after 90 or 100 m up though the surface roughness is higher than Sandwip. The wind data has been collected above 10m height and finally adjusted 50m height by using power law for this analysis.

6.2 Daily, Monthly and Annually Mean Wind Speed Analysis

From the above **Fig.3**, it has been clearly shown that the annual mean wind speed for Kutubdia is higher than Sandwip. It has also shown that the mean wind speeds in Kutubdia were above 5.5 m/s in every year from 2000 to 2006. So,

Kutubdia is the selected site for next analysis. **Fig.4** and **Fig.5** represent the monthly and daily variation of wind speed in Kutubdia. It has been shown that most of the month the wind velocity is more than 5 m/s but in 2001 and 2006 wind speed is more than other. So, most recently available data at 2006 has been analysis by Weibull's distribution for searching wind power potential.

The **Fig.4** has shown the monthly variation of wind speed from 2000 to 2006. It has been clear that in most of the month the wind speed above 5 m/s and in almost every year from April to September wind velocity higher than 5 m/s. But another six month i.e. October to March blows seasonal wind and little bit lower than 5 m/s but not more or remarkable lower. It also shown that the wind speed at 2001 and 2006 has higher than others. From the **Fig.5**, is clearly shown that the mean wind speed from April to September has above 7 m/s which is very good wind pattern for power generation.

6.3 Statistical Analysis of Weibull's 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. It is of utmost interest to theory orientated statisticians because of its great number of special features and to practitioners because of its ability to fit to data from various fields, ranging from life data to weather data or observations made in economics and business administration, in health, in physical and social science, in hydrology, in biology or in the engineering sciences. There are several methods by which Weibull shape factor, k and Weibull scale factor, c can be determined. Three popular methods for calculating Weibull Parameters are (a)Weibull paper method, (b) Standard deviation method, (c) Energy pattern factor method. The shape factor (k) and scale factor (c) were determined for each month which are shown in **Fig.6**. It has been found that the value of k remains in between 1.4 to 3.38 and that of c remains between 2.83 to 6.90. The most of the Weibull functions follow very close to the Raleigh function (k=2) for the selected sites. The two important functions are describe below :

The probability density function means the relative frequency of wind speeds for the site. Therefore, the shape of wind speeds distribution can be guessed when it is plotted. The equation of Weibull Density Function [8] is given by,

$$f(v) = \frac{dF(v)}{dv} = \left[\frac{v}{c}\right]\left[\frac{v}{c}\right]^{k-1} \times e^{-\left(\frac{v}{c}\right)^{k}} \quad \ldots \quad \ldots \quad (2)$$

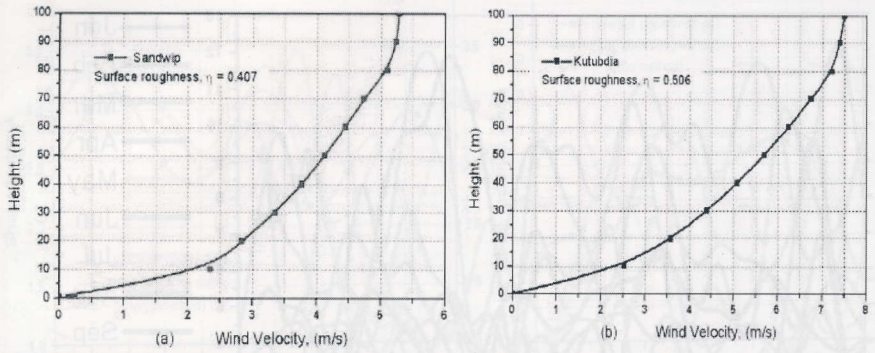


Figure 2: Velocity Profile with Surface Roughness, (a) Sandwip Island, $\eta = 0.407$ and (b) Kutubdia Island, $\eta = 0.506$.

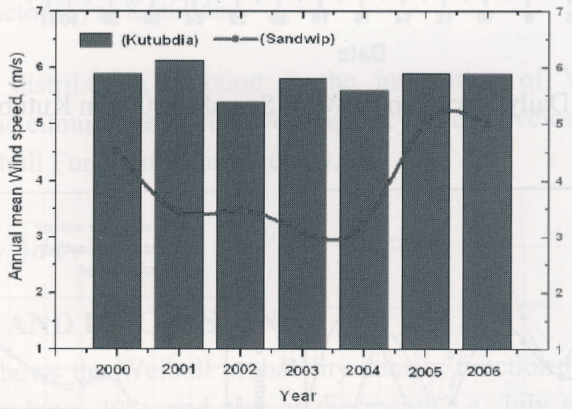


Figure 3: Comparison of Annual Mean Wind Speed for Kutubdia and Sandwip Island.

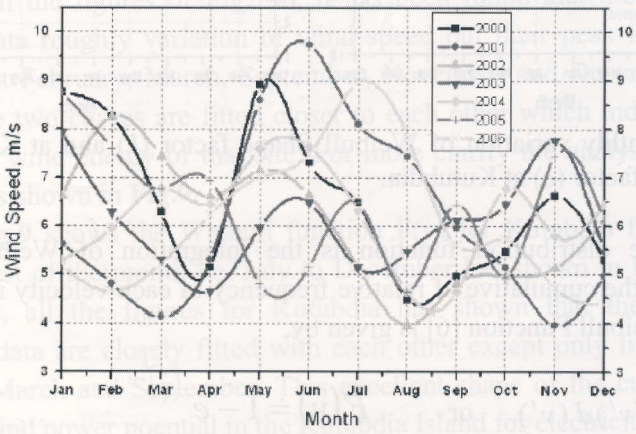


Figure 4: Monthly variation of Wind Speed at Kutubdia (2000-2006).

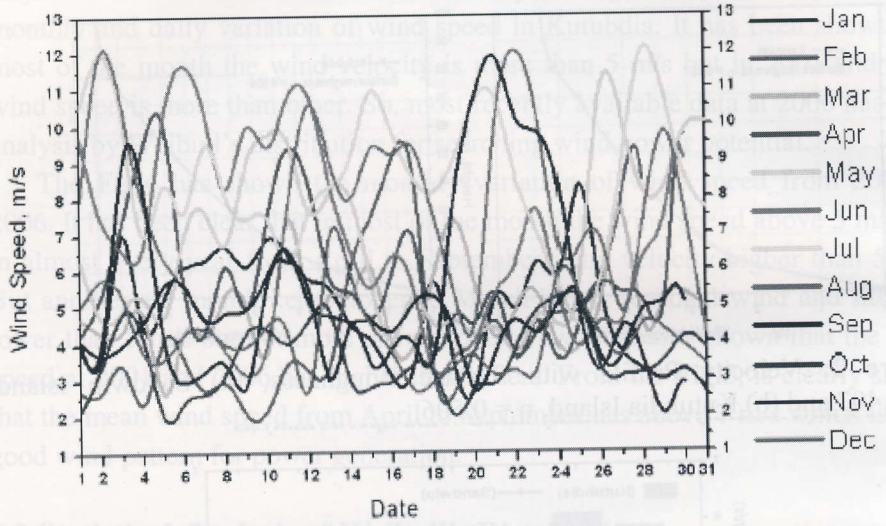


Figure 5: Daily Variation of Wind Speed at 2006 in Kutubdia Island.

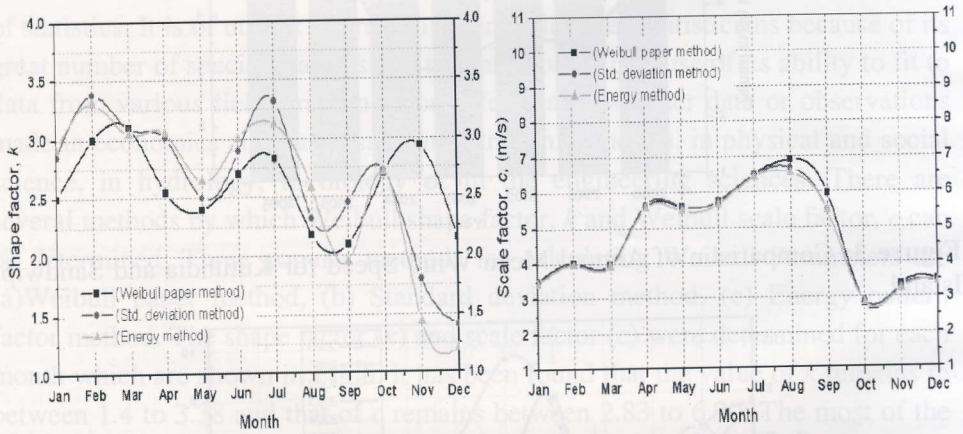
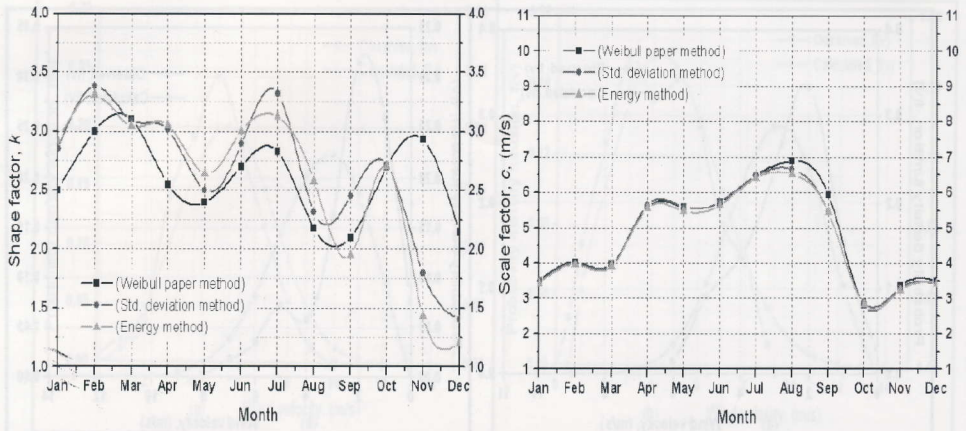


Figure 6: Monthly variation of Weibull Shape factor (k) and at Kutubdia and Weibull Scale factor (c) at Kutubdia.

Cumulative distribution function is the integration of Weibull Density Function. It is the cumulative of relative frequency of each velocity interval. The equation of Weibull Function [6] is given by,

$$F(v) = \int_0^v f(v')d(v') \quad \text{or} \quad F(v) = 1 - e^{-\left(\frac{v}{c}\right)^k} \quad \ldots \quad (3)$$



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7 RESULTS AND DISCUSSIONS

The **Fig.7** shows the Weibull probability density function f(v) for Kutubdia from January to June, 2006 and rest of the month i.e. July to December has shown in **Fig.8**.

From all the figures of **Fig.7–8**, it has been found that the calculated and observed data roughly variation of wind speed but their peak is close to each other except February, March, September, November and December. It's mean that if these two curves are fitted closer to each other which indicates the more prospect of wind energy of that site. For more clarify the analysis of Weibull's function has shown in **Fig.9.**

The **Fig.9** shows the Weibull function F(v) for Kutubdia from January to June and rest of the month i.e. July to December has shown in **Fig.10**. In **Fig.9** and **Fig.10**, all the figures for Kutubdia has shown that the observed and calculated data are closely fitted with each other except only little variation of February, March and September. This excellent shape of the curves represents the more wind power poential in the Kutubdia Island for electricity generation.

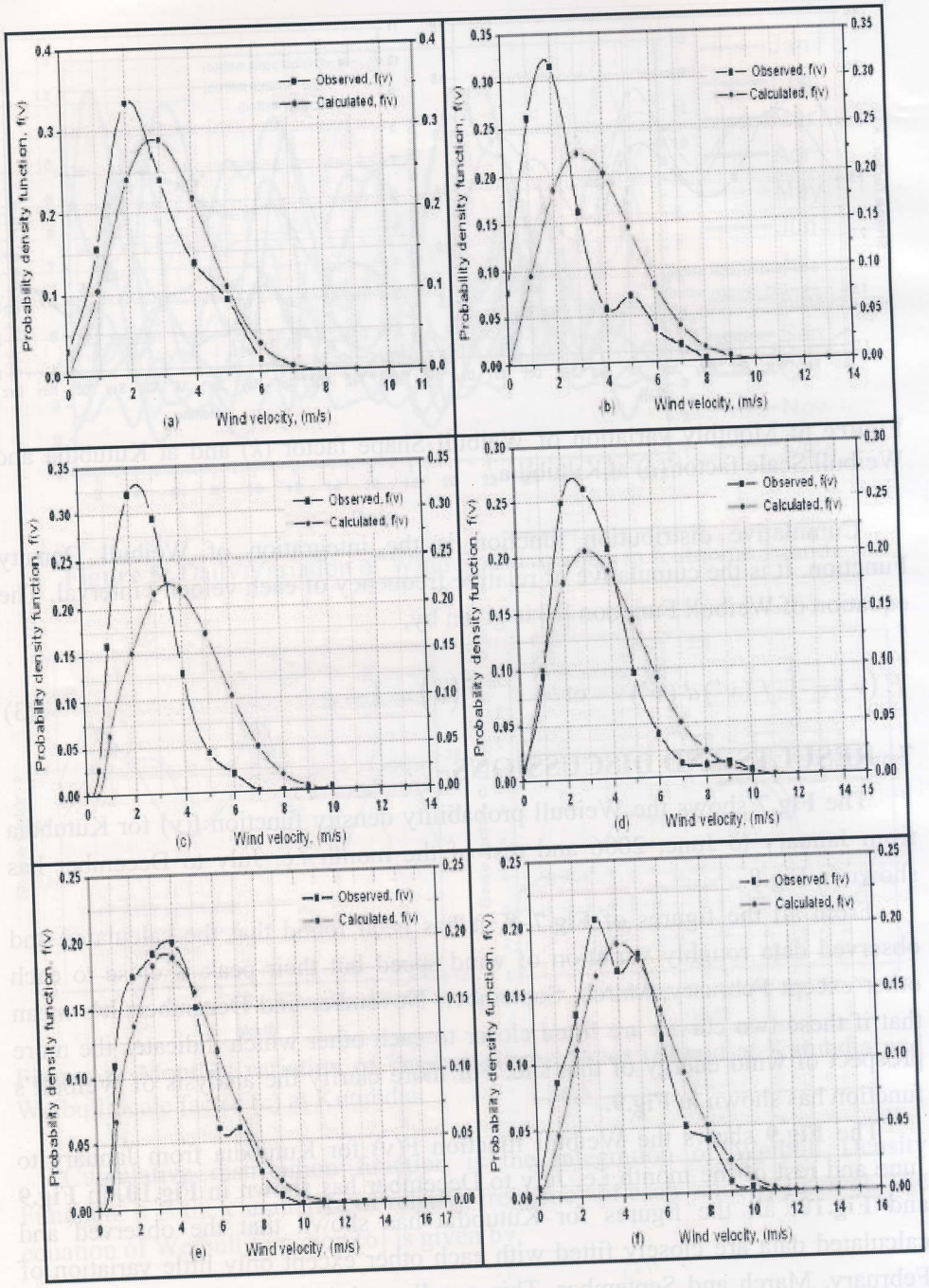

Figure 7: Weibull probability density function **f(v)** for Kutubdia at (a) January, (b) February, (c) March, (d) April, (e) May, (f) June.

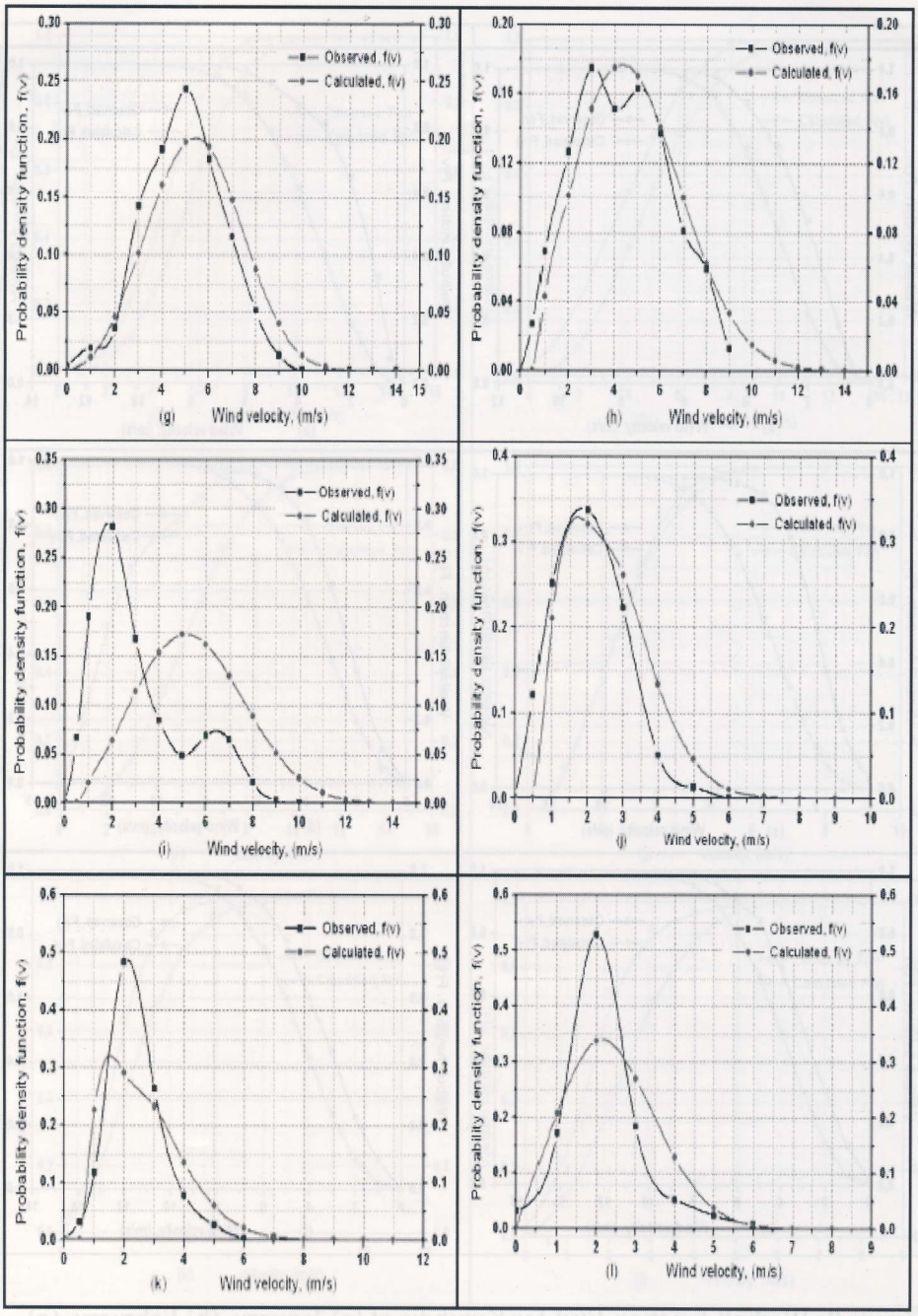

Figure 8: Weibull probability density function **f(v)** for Kutubdia at (g) July, (h) August, (i) September, (j) October, (k) November, (l) December.

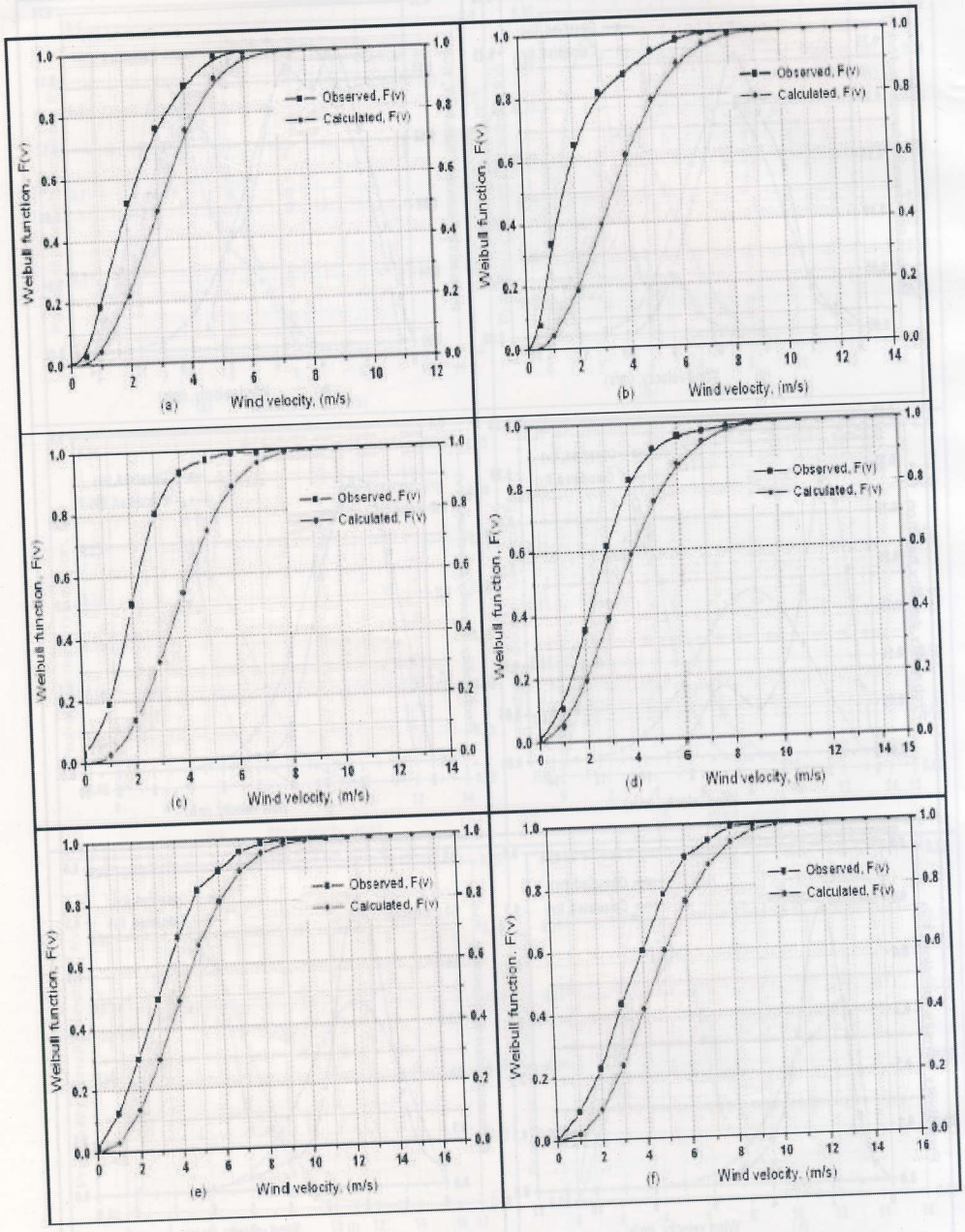

Figure 9: Weibull function **F(v)** for Kutubdia at (a) January, (b) February, (c) March, (d) April, (e) May, (f) June.

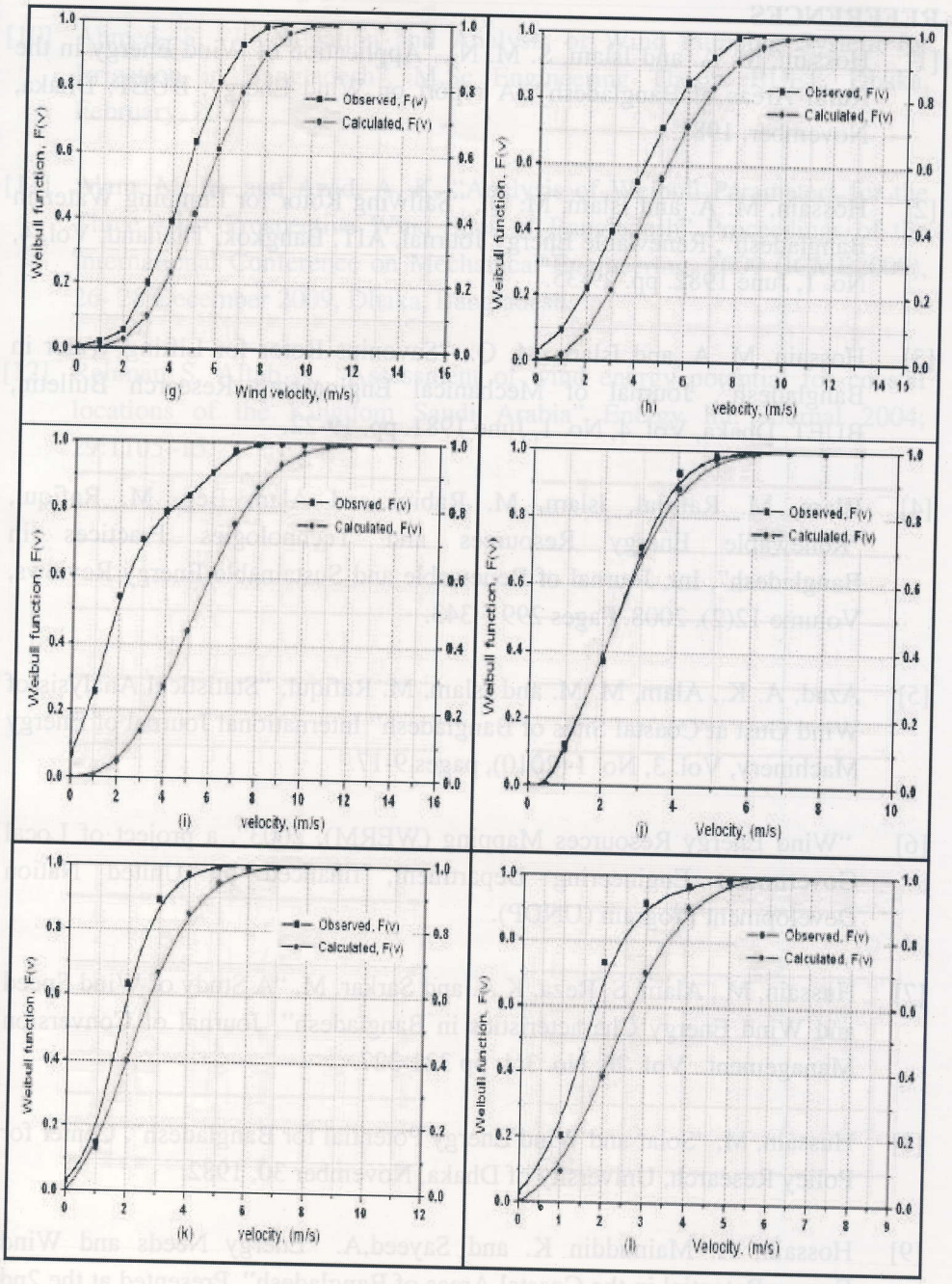

Figure 10: Weibull function **F(v)** for Kutubdia at (g) July, (h) August, (i) September, (j) October, (k) November, (l) December.

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