

Wind Resource Assessment of the North-West Division of Bangladesh

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Abstract - This paper presents a study on the wind power potential of five selected meteorological stations of Rajshahi division, in the northwest of Bangladesh. From the available observed raw wind data long term averages on monthly and annual basis have been obtained, from which probability distribution of wind speed, velocity duration curves and distribution of power in the wind are plotted. Wind roses have also been plotted for the stations. The results indicate that out of the five stations Ishwardi has higher wind potential than the others.

1. INTRODUCTION

Power is utmost important to develop and run a country. Energy, which can produce power, sources are limited and so we need to search for alternative sources. Wind can play an important role in this context. A WMO (World Meteorological Organization) report [1] reveals that 1.75×10^{14} kWh of wind energy is available over the entire globe that can be utilized for betterment of human race. In an earlier work [2] it has been found that monsoon is the main source of the wind in the Barisal division, in the south central part of Bangladesh. In the present work, wind power potential of five, out of six, of the meteorological stations of Rajshahi division, which are in the northwestern part of Bangladesh, has been studied. The stations are at Ishwardi, Rajshahi, Bogra, Rangpur and Dinajpur (Sayedpur has been excluded due to shortage of data). Average monthly wind speeds at these stations are calculated from the three hourly data recorded. Probability distribution of wind speed, probability of wind speed greater than a particular speed, distribution of power in the wind, power per unit area in the wind and power duration curves have been enumerated. All these calculations have been made for all the stations considered.

2. DATA

For the study, data has been acquired from Bangladesh Meteorological Department (BMD). BMD has six stations in the Rajshahi division. They record data every three hours using 3-cup type anemometer kept at standard height of 10 meter. In early days, due to lack of electricity in the sites, they have recorded the data only in daytime. Not also all these stations were commissioned in the same year.

For this study, the data from the commencement of the stations to 2000 is used. (For Sayedpur, data is available only from 1991 and so it has not been considered for this study.). Data were available for Ishwardi since 1961, for Rajshahi 1964, for Bogra 1948, Rangpur 1954 and Dinajpur 1948 respectively (with some missing years). The location of the stations are : Ishwardi $24^{\circ}08' N, 89^{\circ}03' E$; Rajshahi $24^{\circ}22' N, 88^{\circ}42' E$; Bogra $24^{\circ}51' N, 89^{\circ}22' E$, Rangpur $25^{\circ}44' N, 89^{\circ}14' E$, and Dinajpur $25^{\circ}39' N, 88^{\circ}41' E$.

3. METHODOLOGY

The collected raw data has been processed to get one year long term average at the observational hours (using only the available observations). The raw data which were in knots/hr, are transferred into m/s. With class interval of 0.25 m/s a frequency table is made (not shown). Using the frequency table probability distribution of wind speed (relative frequency), probability of wind speeds greater than a particular speed (cumulative relative frequency) and distribution of power in the wind are tabulated (not shown). The power per unit area of wind cross-section is given by

$P_0 = \frac{1}{2} \rho u^3$. Considering air density $\rho = 1.165 \text{ kg/m}^3$ and wind speed u in m/s, we get $P_0 = 0.58 u^3 \text{ W/m}^2$. Let Φ_u is the probability distribution of wind speed u , then the distribution of power in the wind becomes $P_0 \Phi_u$.

4. RESULTS AND DISCUSSION

The long term monthly averages (from the commission date of the stations up to 2000) of wind speed for the five meteorological stations of Rajshahi division of Bangladesh are plotted in Fig. 1. It shows that all of the stations experiences their respective lowest winds through post-monsoon (October-November) to winter (December-February). From the starting of pre-monsoon (March-May) the speed starts to climb up and attains their maximum by April and remains nearly constant throughout the months from May-August, then it gradually decreases till to October. It is also interesting to note that at the higher latitudes the wind speeds less than that of lower latitudes.

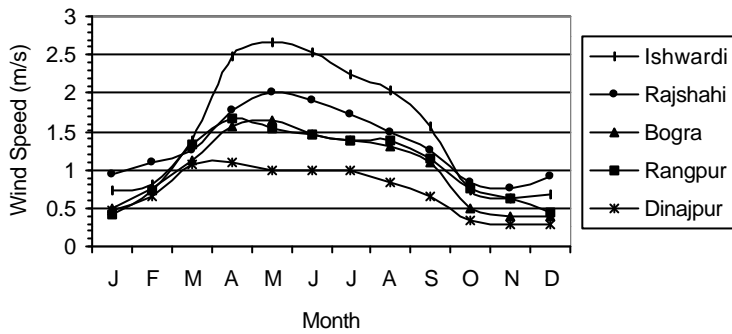


Figure 1: Average monthly wind speeds of the five stations of Rajshahi division.

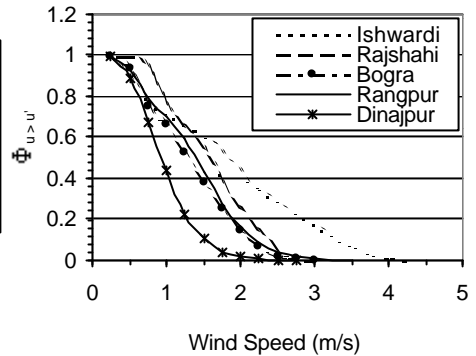


Figure 3: Probability of wind speed greater than a particular speed u' .

The probability distributions of wind speeds are plotted in Fig. 2. It indicates that Ishwardi has wide variety of winds. On the other hand, Dinajpur has lowest variability. The modes of the distributions are at 0.60, 1.40, 1.05, 1.20 and 0.75 for the stations Ishwardi, Rajshahi, Bogra, Rangpur and Dinajpur respectively.

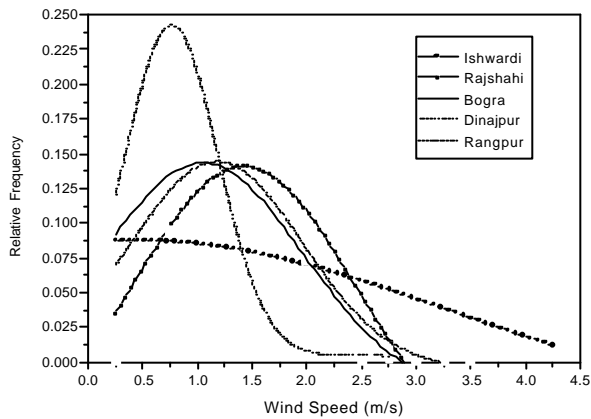


Figure 2: Probability distribution of wind speed.

The cumulative relative frequency against wind speed is plotted in the Fig. 3. These curves also give the median of the distributions of Fig. 2. For Ishwardi, Rajshahi, Bogra, Rangpur and Dinajpur, the respective values are 1.82 m/s, 1.57 m/s, 1.29 m/s, 1.40 m/s and 0.93 m/s.

Fig. 4 represents the distribution of theoretical power in the wind. The respective picks are at 3.30 m/s, 2.22 m/s, 2.00 m/s, 1.82 m/s and 1.25 m/s for Ishwardi, Rajshahi, Bogra, Rangpur and Dinajpur.

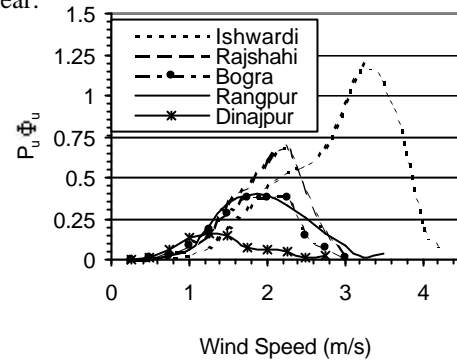


Figure 4: Distribution of Power in Wind.

In Fig. 5 power per unit area in the wind against the probability of wind speed greater than a particular speed is plotted. It indicates the likelihood of obtaining particular power levels. For example, the probability of getting 20 watt/m² power is 14% for Ishwardi.

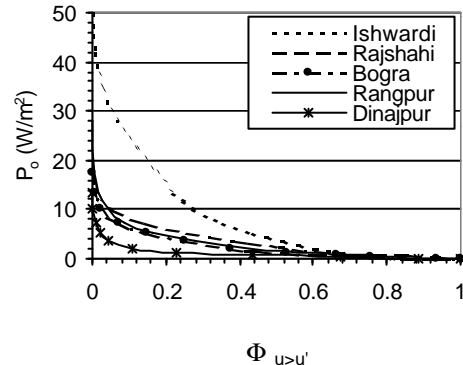


Figure 5: Power per unit area in the wind against the probability of wind speeds greater than a particular speed u' .

The wind duration curve is plotted in Fig. 6. From these curves, it is possible to obtain the time availability (at percentage) of wind speeds. For example, if we want to see the availability for getting

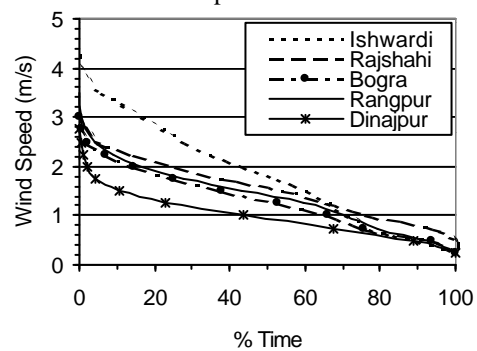


Figure 6: Wind duration curve.

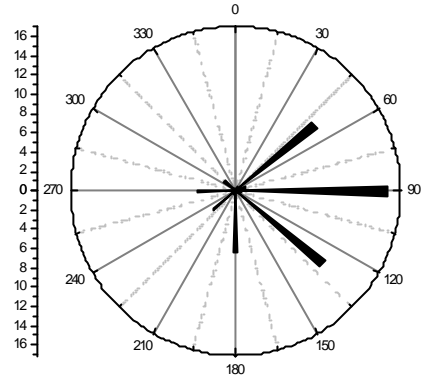
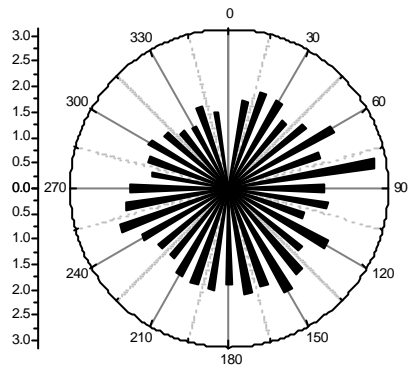


Figure 7 : Wind roses of Rangpur : wind speed (left) and percentage of occurrences (right).

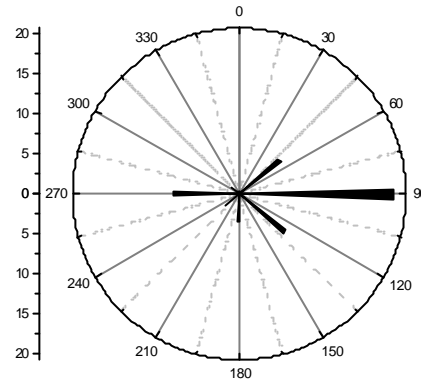
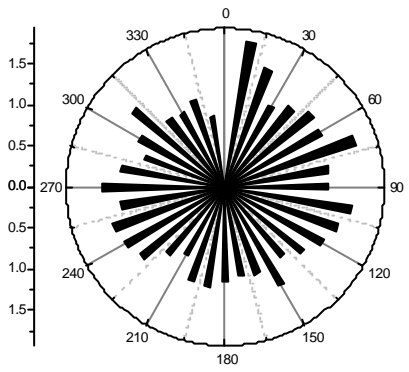


Figure 8: Wind roses of Dinajpur : wind speed (left) and percentage of occurrences (right).

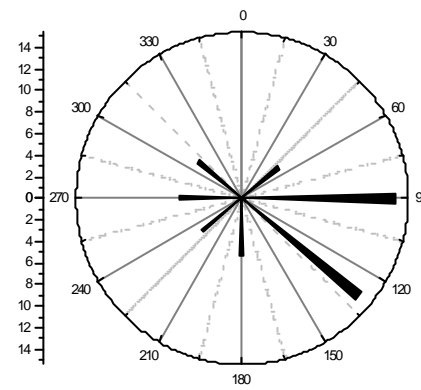
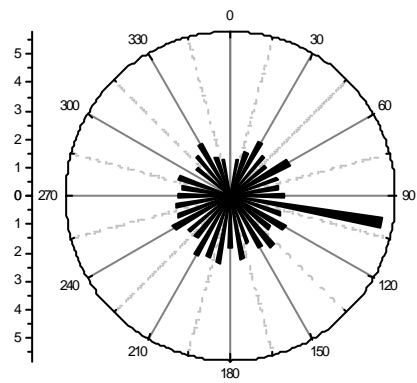


Figure 9: Wind roses of Bogra : wind speed (left) and percentage of occurrences (right).

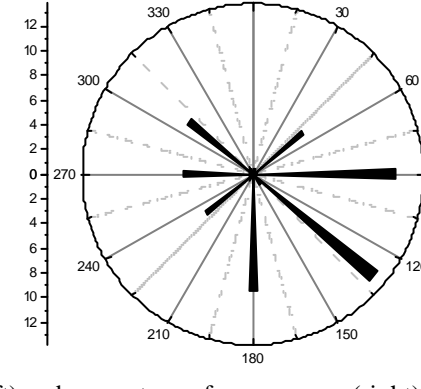
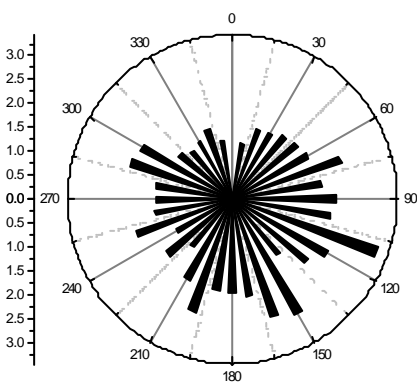


Figure 10: Wind roses of Rajshahi : wind speed (left) and percentage of occurrences (right).

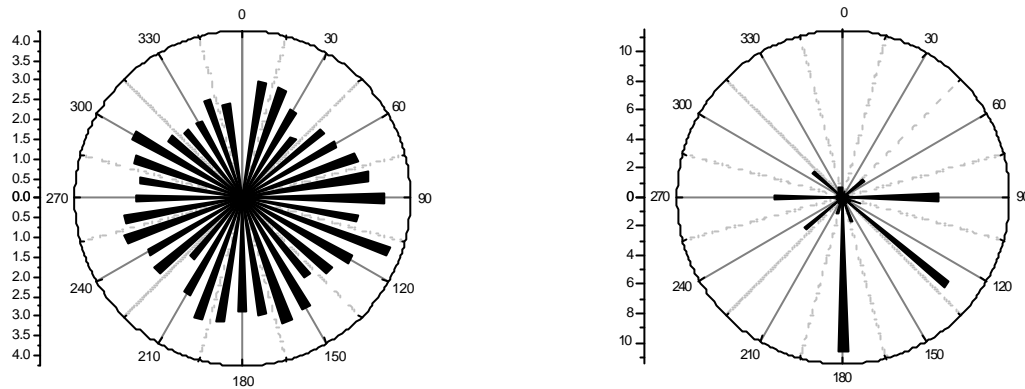


Figure 11: Wind roses of Ishwerdi : wind speed (left) and percentage of occurrences (right).

The wind roses of the five stations are plotted in Fig. 7 – Fig. 11.

For the station Rangpur though a maximum speed of 2.33 m/s was available but its occurrence was 0.11%, on the other hand though the wind speed from East (90°) was 1.87 m/s, its occurrence was 15.84%. The other notable percentages, direction, speeds are 11.69%, 130° , 1.85 m/s and 10.66%, 50° , 1.91 m/s.

For Dinajpur, the maximum speed was only 1.73 m/s, coming from 90° and its occurrence was only 0.02%. For this station the notable percentage, direction and speeds are 19.19%, 90° and 1.25 m/s; 7.24%, 130° and 1.22 m/s; and, 6.50%, 50° and 1.37 m/s.

For Bogra, a maximum of 9.25 m/s wind speed from 300° was present with 0.02% of occurrence and perhaps is incidental. For it 14.29% with speed 1.86 m/s was available from 90° . In terms of occurrence, only other notable is 14.04% with speed 1.75 m/s and coming from 130° .

For Rajshahi the maximum wind speed was 3.19 m/s but its occurrence was only 0.20%, on the other hand the maximum occurrence 12.80% was of speed 2.00 m/s from 130° . The other notable percentages, direction, speeds are 11.58%, 90° , 2.15 m/s; 9.61%, 360° , 1.26 m/s and 9.37%, 180° , 1.97 m/s.

For Ishwardi winds of speeds more than 3.0 m/s were more frequent, coming from 12 directions (out of 36 possible directions considered) and only from 2 directions wind speeds were less than 2 m/s. For it, a maximum of 3.95 m/s with occurrence 1.25% coming from 110° was present. For this station, the notable percentage, direction, and speeds are 11.63%, 180° and 2.87 m/s; 9.32%, 130° and 2.87 m/s; and, 6.54%, 90° and 3.58 m/s.

5. CONCLUSIONS

This analysis reveals that,

- Monsoon is the main source of the wind in the area under consideration.
- In Ishwardi, it is possible to get winds of speed 2.00 m/s or more for at least 44% time all through the year.
- With the increase of latitude, maximum occurrence of wind rotates from south to east.

ACKNOWLEDGEMENT

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