Assessment of Offshore Wind Farm Potential Near Saint Martin, Bangladesh, Using Statistical Data Analysis

Md. Ariful Islam[1], Shanto Naha[2], Jiaur Rahman[3] and Md. Shahidul Islam[4]

[1] Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology
Dhaka, Bangladesh
Email: 1912023 [AT] name.buet.ac.bd

[2] Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology
Dhaka, Bangladesh
Email: 1912006 [AT] name.buet.ac.bd

[3] Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology
Dhaka, Bangladesh
Email: jiaur2344 [AT] gmail.com

[4] Department of Naval Architecture and Marine Engineering, Bangladesh University of Engineering and Technology
Dhaka, Bangladesh
Email: shahid777 [AT]name.buet.ac.bd

ABSTRACT— ***Bangladesh is one of the world's most populous countries, and its economy is mainly dependent on agriculture. As a result, there is a scarcity of land here. As a developing country, Bangladesh has a huge demand for energy, as it plays a key role in health, nutrition, water access, infrastructure, education, and even life expectancy. For a nation to move from developing to developed, it needs access to sufficient energy. Furthermore, with the climate crisis, all nations must transition to renewable energy sources to power the future. The Bangladesh government intends to generate a significant amount of the country's electricity from renewable resources. Wind can be a source of renewable energy. Onshore locations have only an average wind speed. In addition to low average wind speeds, certain places endure high winds during typhoons, flooding, and poor grid stability. With a high population causing a shortage of viable land, offshore wind farms can play a vital role in meeting renewable energy targets. This paper assesses Bangladesh's offshore wind energy potential, aiming to identify a suitable location for wind power generation. Using meteorological data and geographic analysis, potential offshore places for wind farms with favorable conditions are identified. The study also emphasizes the crucial aspect of cyclones and their influence on offshore wind farms, focusing on the necessity of planning to address these environmental challenges. The results indicate that the region possesses favorable wind conditions, particularly at a height of 50 meters, with an average wind speed of 4.515 ms^{-1}, making it viable for sustainable energy production. The analysis also highlights the natural shielding effect of Saint Martin Island, which reduces cyclone intensity in certain areas, enhancing the site's feasibility.***

Keywords— renewable energy, offshore, wind farm, potential

1. INTRODUCTION

Bangladesh, a developing country, has one of the world's fastest-growing economies. It has a mixed economy and has reached lower-middle-income status in recent years. Energy plays a vital role in developing nations. In fact, the consumption of energy per capita is linked to health, wealth, nutrition, water access, infrastructure, education, and even life expectancy. Indeed, for a nation to progress from developing to developed, it requires reliable and affordable energy. The largest consumers of electricity are the industrial and residential sectors, followed by the commercial and agricultural sectors. Furthermore, with the climate crisis demanding our attention, all nations must transition to renewable energy sources to power their futures. Bangladesh's electric power requirements are projected to grow significantly in the coming years. By 2030, the country is expected to need around 34,000 megawatts (MW) of power to support its economic growth, which is anticipated to exceed 7% annually. Currently, the installed capacity stands at approximately 25,700 MW as of June 2022, indicating a substantial gap that needs to be addressed [1]. The transition to renewable energy also supports limiting global warming to below 1.5°C [2]. Wind energy is becoming an increasingly popular source of renewable energy because it is pollution-free, sustainable, and cost-effective. As a result, it is gaining increasing attention worldwide and has grown tremendously. Technological developments have aided this growth, but the performance of wind farms depend on optimal turbine placement. However, wind farms performance is minimized by wake effects - where downstream turbines experience reduced wind speeds due to inter turbine interference. The Jansen wake model is used to analyze wake effects due to its simplicity and effectiveness [3]. Micro siting optimization techniques like genetic algorithms have been widely used [4]. Genetic algorithm is used for optimizing wind turbine distribution and exploring numerous configurations without being constrained by local optima [5]. From April to May and October to November, cyclones recur in the southern part of Bangladesh, specifically in the Bay of Bengal [6]. A safe zone with less cyclonic impact is significant for deploying offshore wind farms in Bangladesh. Cyclones generate low-pressure systems which, coupled with strong winds, raise the sea level. So, identifying a safe place is the first step in deploying an offshore wind farm. Wind turbines can be at significant risk from the effects of cyclones; there is a study about the damage from a typhoon on a wind farm in Japan, focusing on failure modes and recommendations for improved design [7]. This study mainly focuses on the potential of the area near Saint Martin Island, analyzing wind speed, wind direction, natural disaster analysis, depth of the water as well as the seabed condition. Some basic ideas on why these factors are necessary to be considered are discussed below.

Wind Speed Variation

Wind speed and direction data need to be analyzed to determine the feasibility of an offshore wind farm. A wind farm must operate or generate electricity for a sufficient portion of the year to supply electricity to the national grid, requiring to verify the availability of the minimum wind speed to generate electricity for a longer period of the year. So, it is necessary to analyze annual wind data that is unique to define a location. Annual wind variation in offshore wind farms is examined using historical data analysis. The analysis provides variation in wind patterns over time and long-term dependability and performance of offshore wind generating installations.

Natural Disaster Analysis

Cyclones have a considerable impact on the location of wind farms. Understanding these impacts is vital for guaranteeing the safety and efficiency of these renewable energy source installations. The southern part of Bangladesh is at high risk of cyclones. So, cyclone path analysis is done to ensure the safe placement of offshore wind farms.

Tidal bore Effect

A tidal bore is a sudden and strong tide that can impact offshore wind farms by affecting water currents and wave conditions. It produces more turbulence and additional loads on the support structure and turbines.

Depth

Water depth is an important factor in the selection of a potential wind farm location [8]. Shallow waters are often favored due to ease of installation and maintenance. Based on bathymetry data, however, deeper waters require specialized equipment. Deeper waters need more complex and costly foundation types, such as floating platforms. The hub height measures the distance between a wind turbine's base and rotor center. A longer hub height is required for deep water than for shallow water.

Seabed Condition

Seabed condition is an important factor for offshore wind farms. To support wind turbines, a stable seabed is required because it is essential for the reliability and effectiveness of the wind farm. The seabed is affected by wind and waves, so it needs to be maintained a secure foundation so that offshore wind farms can withstand the dynamic nature of the sea. In shallow water, turbines are fixed to the seabed. On the other hand, in deep water, as they are not fixed to the seabed, they can be designed with taller hub heights to capture higher wind speeds at elevated levels.

2. METHODOLOGY

It is already established that to increase electricity production, offshore wind farms can be one of the most viable options. The initial step in establishing such a farm is choosing a suitable place, which requires consideration of several factors, including wind speed variation, risks of natural disaster, tidal bore effects, water depth, and seabed conditions as discussed in the previous section. First and foremost, it is necessary to select a location with consistently high wind speeds throughout the year. This involves gathering data and plotting a curve representing the monthly average wind speed variation at a height of 50 meters. For that height, a wind rose diagram must be developed. Subsequently, it is essential to create a wind speed distribution curve for that height and produce a contour plot of these data. Wind roses at a height of 50 meters should also be created for each month from January to December for a comprehensive analysis.

Similarly, the research should include the generation of monthly average wind speed variation curves, wind roses, wind speed distribution curves, and contour plots for the 10-meter height. This is done to verify that higher wind energy is available at higher height, such as at 50 m. The wind speed and direction data for this study were obtained from the NASA POWER project [9]. The dataset spans from January 1, 2014, to December 31, 2023, and includes hourly measurements for the coordinates 20.6004°N, 92.3426°E.

Furthermore, it is necessary to consider historical cyclone paths and choose a place with a lower cyclone effect to ensure the wind farm's lifetime and stability. Again, the depth of water needs to be considered to ensure the reliable and effective installation of wind turbines because water depth plays a significant role, as the installation process differs between shallow and deep waters. Another factor is seabed condition; a stable seabed is required to sustain wind turbines and guarantee the wind farm's long-term stability and effectiveness [10]. Finally, the tidal bore is another factor that may cause extra stress on the turbines and influence their longevity and performance.

In this respect, the variability of wind speed and direction was prepared by collecting wind data in hourly scale variations at two heights of 10 and 50 meters; data were gathered in comma-separated values format. The raw dataset contained an added single-column date-time for efficient and minute-by-minute temporal handling of the output. Subsequently, overall, seasonal, and month-wise wind directional patterns were analyzed. The second step in the analysis was to compute the monthly mean wind speed and directions with line graphs showing trends and peak periods. In the third step, wind data was categorized into four major seasons of Bangladesh, namely Summer, Monsoon, Autumn, and Winter, to determine the most productive period for wind energy generation. Contour plots were created last to visually show the diurnal and seasonal variations of wind speed by hour and month for both heights. All visualizations of data were then enhanced through clear labels, legends, and grids with significant emphasis on color-coded figures of great trends. The tools used for analysis included Pandas in data preprocessing, Matplotlib and Seaborn for plotting, while directional analysis was done with Windrose. An overview of the flow in wind data analysis is given in Figure 1.

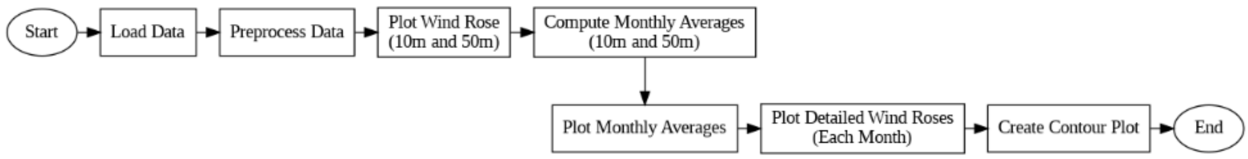


Figure 1: Flowchart of Data Analysis

3. RESULTS

The area of Saint Martin was found to be feasible for wind farm installation based on the analysis of wind speed, cyclone path, and water depth. At 50 meters, the speeds ranged from 5.1 to 15.3 ms^{-1}, with the highest energy potential during the monsoon seasons, but during winter, the winds are stable yet moderate. Cyclone path analysis indicated reduced cyclone intensity behind Saint Martin, offering natural protection. The site's water depth of approximately 6 meters falls within the shallow water foundation range, ensuring economic feasibility. These factors collectively establish the region as a promising location for wind energy generation.

3.1 Wind Speed Variation

A place has to be selected where adequate wind speed is available for the turbine to operate for a long period of time in the year. For a wind turbine to operate, a minimum required wind speed, called cut-in speed, is about 2.5 to 3 ms^{-1} [11]. So, the place should have this amount of wind available.

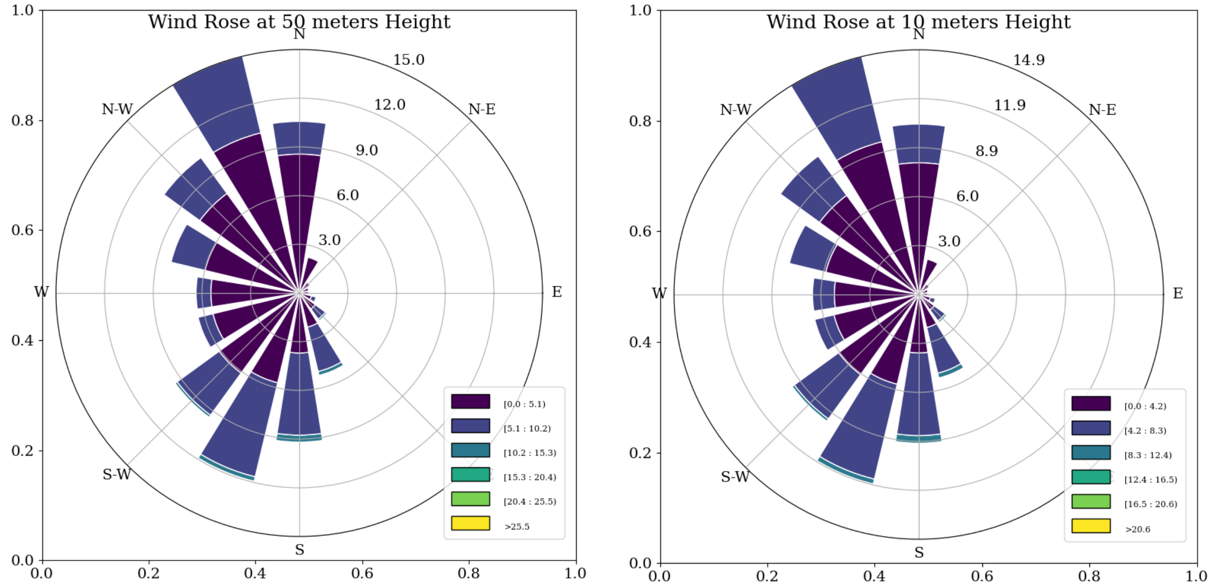


Figure 2: Wind Rose at 50 meters and 10 meters height

The radial axis of wind rose graph represents wind direction in degrees, with 0° being North at the top, 90° East on the right, 180° South at the bottom, and 270°-West on the left. The concentric circles indicate the frequency percentage of wind blowing from each direction. The outer circles show higher frequencies. The bars extending from the center indicate the frequency of wind speeds for each direction, with their lengths proportional to the percentage of time the wind blows. The colors of the bars indicate wind speed ranges, in ms^{-1}, from 0.0–5.1 ms^{-1} in dark purple to 15.3–25.5 ms^{-1} in green and yellow.

The wind rose graphs compare wind speed and directional patterns at 50 m and 10 m heights. At 50 meters, the predominant wind direction is northwest (NW), with speeds mostly between 5.1–15.3 ms^{-1}, and a smaller portion exceeding 15.3 ms^{-1}. At 10 meters, NW winds also dominate, but wind speeds are generally lower, primarily between 4.2–12.4 ms^{-1}, with fewer instances exceeding 12.4 ms^{-1}. At 50 meters, the winds are stronger and steadier, hence taller turbine placements can capture significantly more energy (Figure 2).

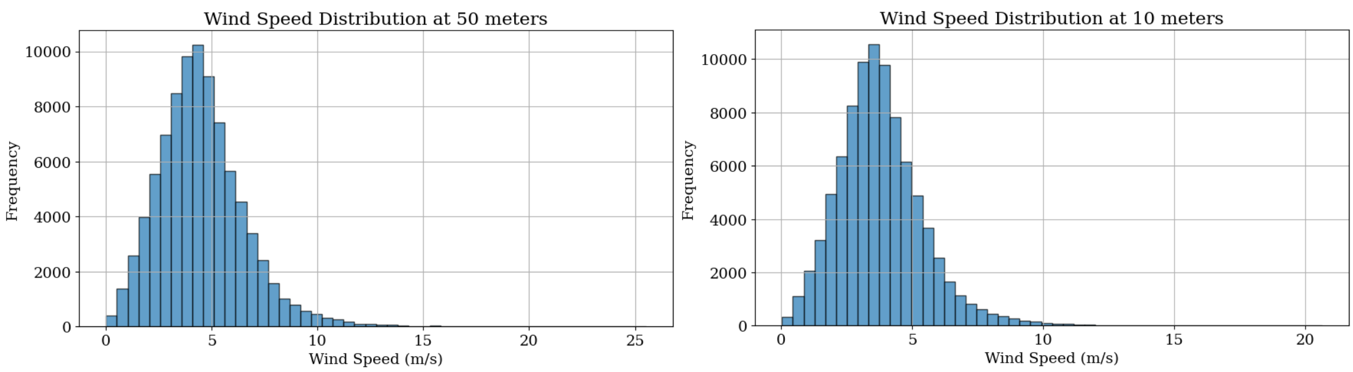


Figure 3: Wind Speed Distribution at 50 meters and 10 meters.

The distribution of the wind speed at 50 meters and 10 meters indicates similarities. In both distributions, most of the wind speeds were grouped around a central range: between 3.5 to 5.5 ms^{-1} for 50 meters, while it fell somewhat lower to 2.5–4.5 ms^{-1} for 10 meters. Both show a slight right-skew with higher wind speeds that indicate occasional strong winds. Whereas at 50-meter height, the wind speeds are higher at each point with high energy potential; thus, the height can be suitable for wind energy generation (Figure 3).

3.1.1 Seasonal Wind Analysis

Bangladesh has four seasons according to meteorological classification: Autumn, Monsoon, Summer, and Winter, based on information from the Bangladesh Meteorological Department [12]. Changes in the direction and speed of the wind determine whether an offshore wind farm is feasible [13].

Winter

Wind rose diagrams for the winter season (December, January, and February) at 10 m and 50 m heights are presented in this section. As shown in Figure 4, winds blow consistently at 50 m height, with some dominated by the northwest direction. The percentage occurrences of such NW winds remained at 33.2% in December, and increased to 37.1% in January, the month that also exhibited a maximum wind. During this time, the strongest wind speeds range from 3.5 –6.9 ms^{-1}. February shows a slight decrease in the frequency and speed of the winds, with NW winds at 29.9% and more moderate speeds averaging 3.5 ms^{-1} –5.2 ms^{-1}. During these three months, the NW direction is the most important, with secondary contributions from north-northwest (N-NW) and north (N). The winter months manifest reliable wind regimes for energy conversion, while the month of January is usually the most promising during this period.

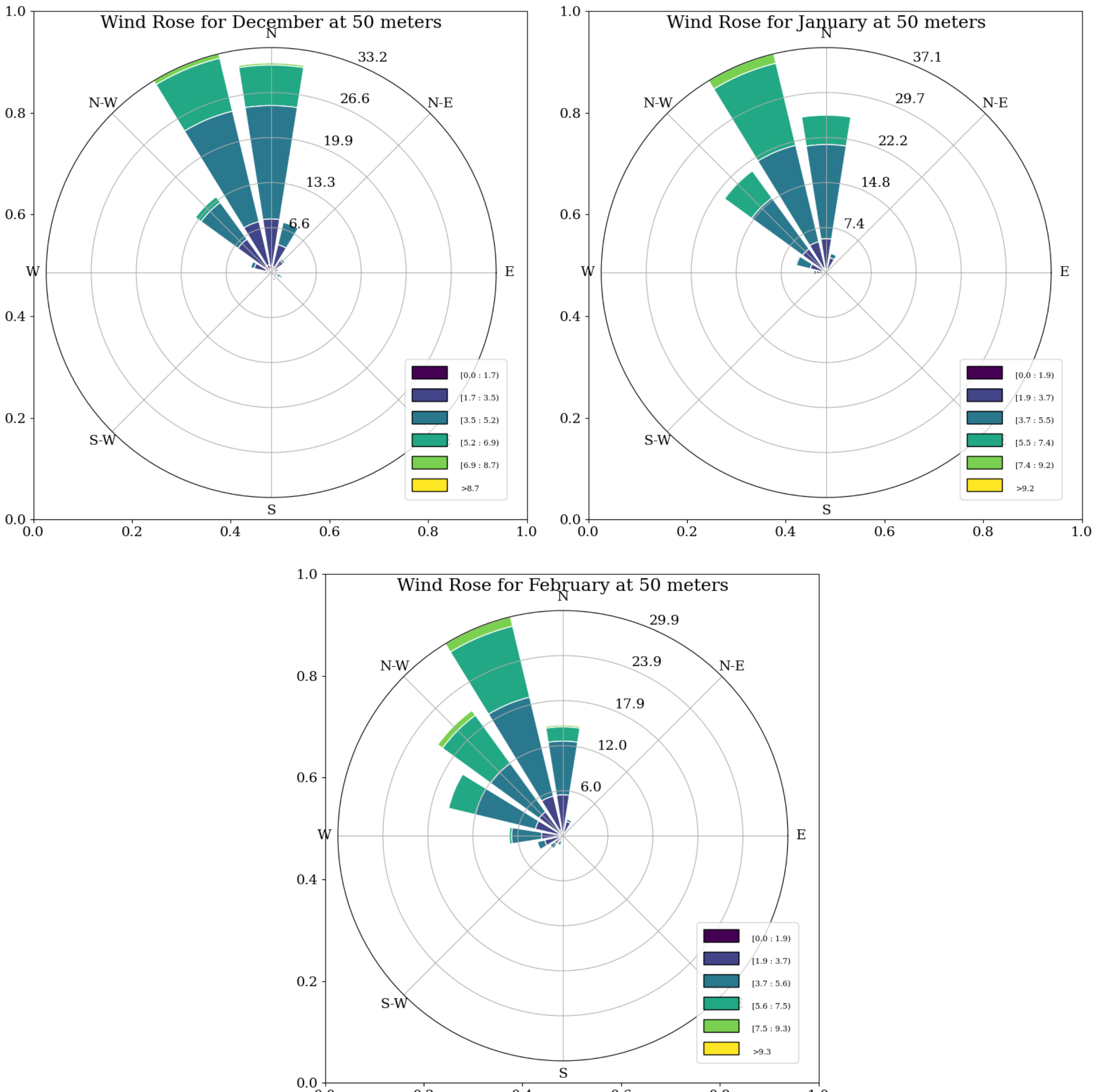


Figure 4: Wind Rose for Winter at 50 meters (December, January, February)

The wind rose graphs for winter (December, January, February) at 10 meters illustrate a consistent dominance of northwest (NW) winds across all months. Figure 5 shows that in December, NW winds occur 33.6% of the time, followed by north-northwest (N-NW) at 26.8%, with speeds predominantly in the 3.0–5.9 m/s range. January shows the strongest winds, with NW winds reaching 37.2% frequency and speeds of 4.7–6.3 ms^{-1}, making it the most productive month for energy generation. By February, NW winds decrease slightly to 29.6%, with speeds mainly between 3.0 and 4.7 ms^{-1}, indicating a seasonal decline. N and N-NW provide secondary contributions, while NW continues to be the dominant direction. Although 10-meter winds are moderate, they are sufficient to run turbines, and January has the most energy potential because of the stronger and more reliable winds.

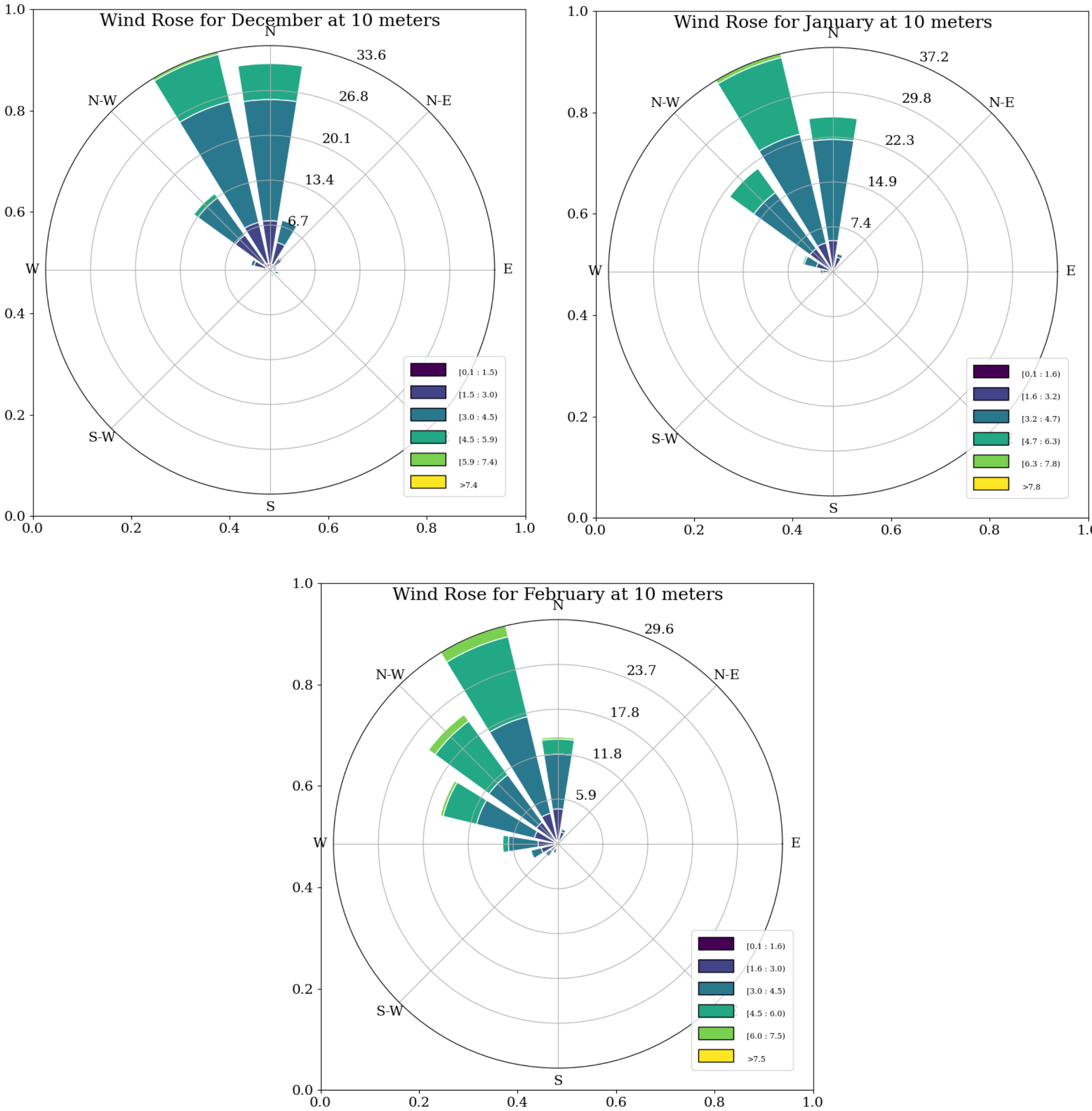


Figure 5: Wind Rose for Winter at 10 meters (December, January, February)

Summer

The wind rose graphs for summer (March, April, May) at 50 meters show shifting wind patterns and speeds. Figure 6 shows in March, northwest (NW) winds dominate (23%) with speeds of 3.6–7.4 ms^{-1}. April marks the peak energy potential with westerly (W) and northwest (NW) winds contributing up to 17.4% and speeds reaching 9.1 ms^{-1}. May is the least active month, with westerly winds predominating at slower rates (1.9–5.5 ms^{-1}). April is the most productive month, as evidenced by the shift from NW to W winds. For best summer performance, turbine orientation favors westerly winds.

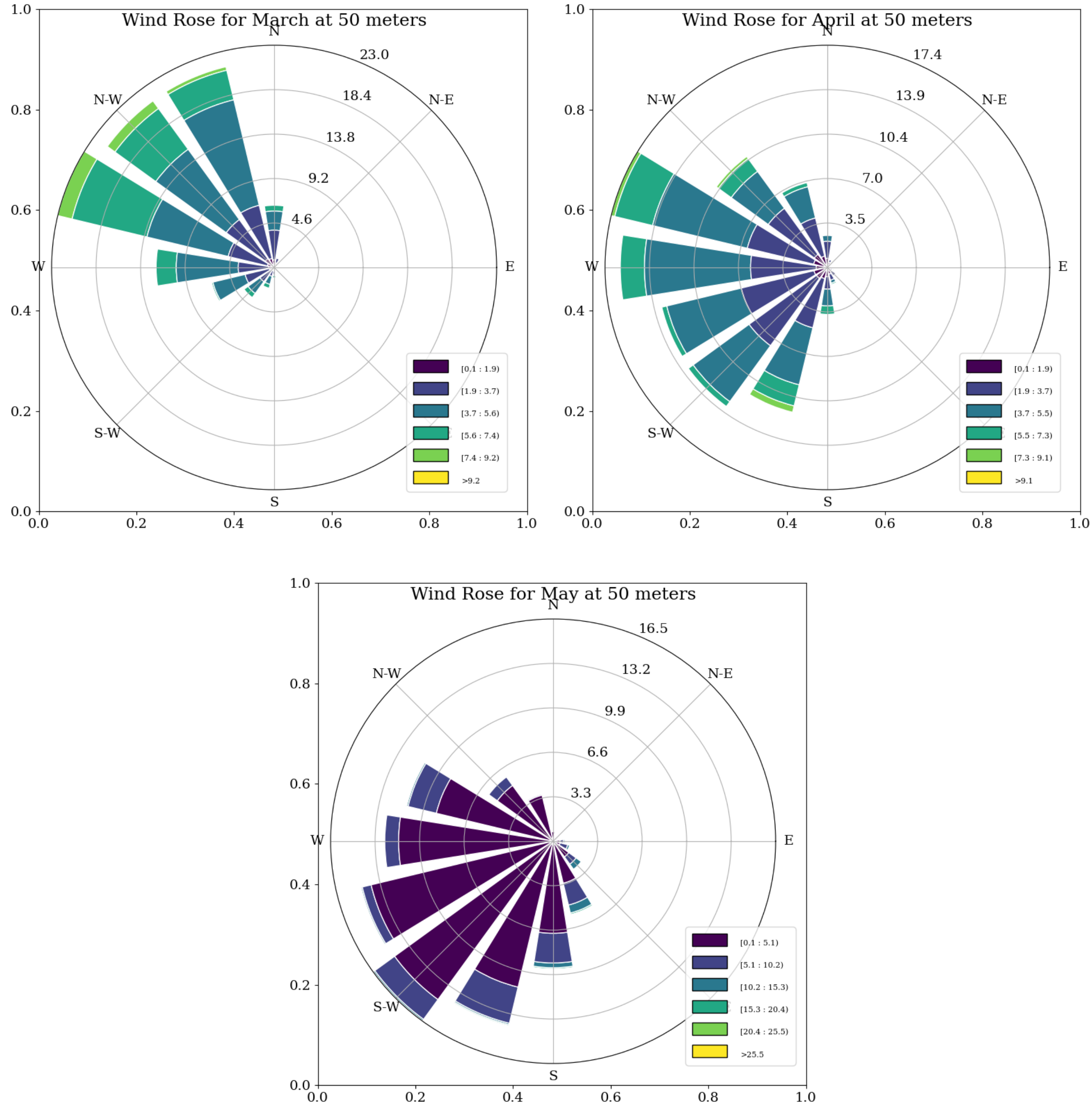


Figure 6: Wind Rose for Summer at 50 meters (March, April, May)

The 10-meter wind rose graphs during the summer months of March, April, and May show fluctuating wind patterns and modest speeds (Figure 7). Northwest (NW) winds predominate in March (22.8%), primarily traveling at 2.7–6.3 ms^{-1}. Wind energy potential peaks in April, when westerly (W) and northwest (NW) winds predominate (up to 17.3%) and reach 4.6–7.6 ms^{-1}. In May, winds are purely westerly, with relatively low speeds of 1.6–4.8 ms^{-1}, leading to its lowest yield or production during that month. Considering energy generated at 10 meters, April is the most favorable.

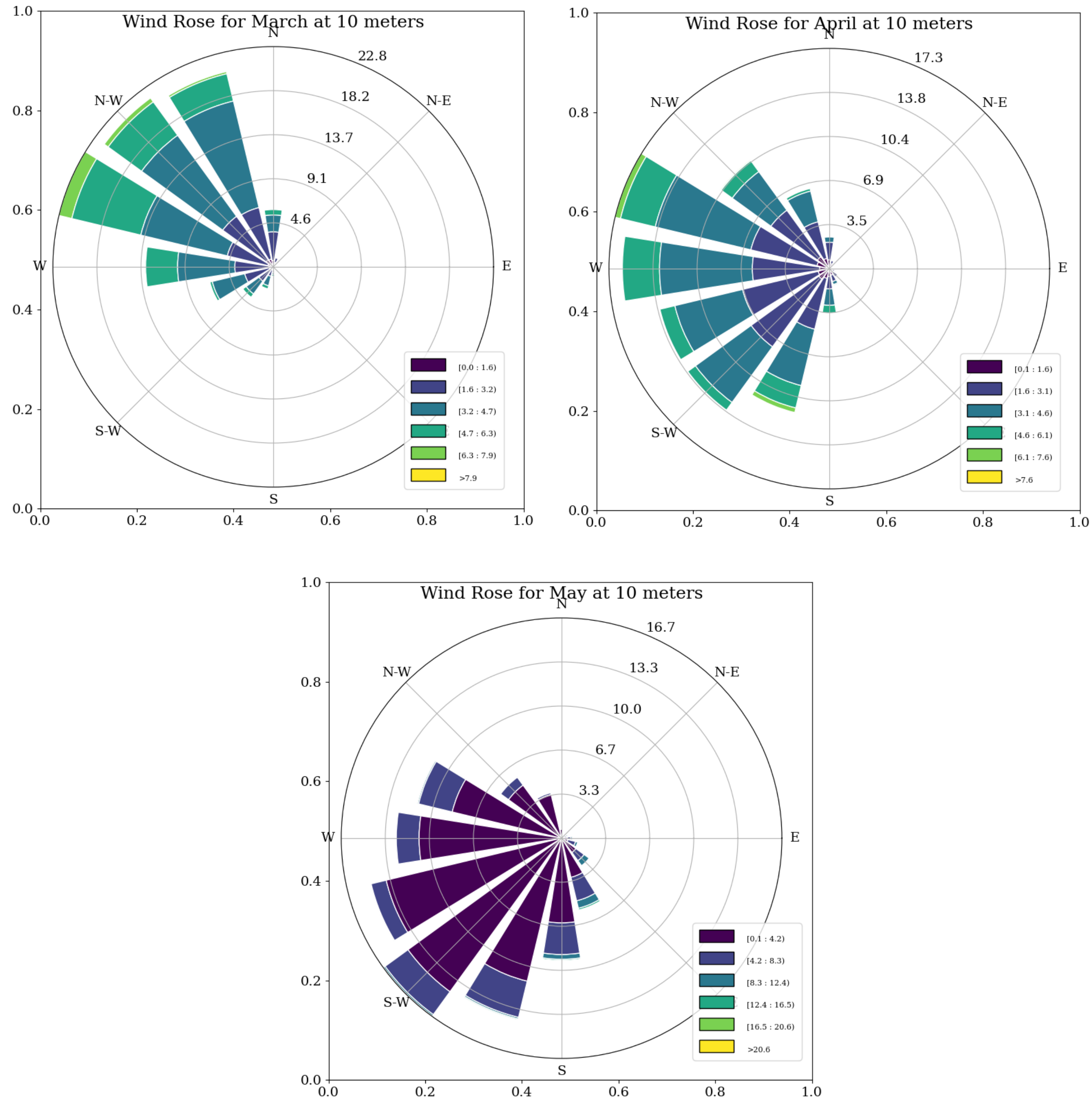


Figure 7: Wind Rose for Summer at 10 meters (March, April, May)

Monsoon

The wind rose graphs for the monsoon season (June to September) at 50 meters highlight dominant westerly (W) and southwest (SW) winds with high energy potential (Figure 8). June and July are the most productive months, with W winds reaching 31% frequency and speeds peaking at 7.0–18.0 ms^{-1}. August sees a slight decrease, with W winds at 26.4% and speeds of 7.0–14.3 ms^{-1}, while September marks the transition out of the monsoon with reduced W winds (17.7%) and speeds of 3.0–10.3 ms^{-1}. Westerly alignment is highly important to optimize the energy capture in this season.

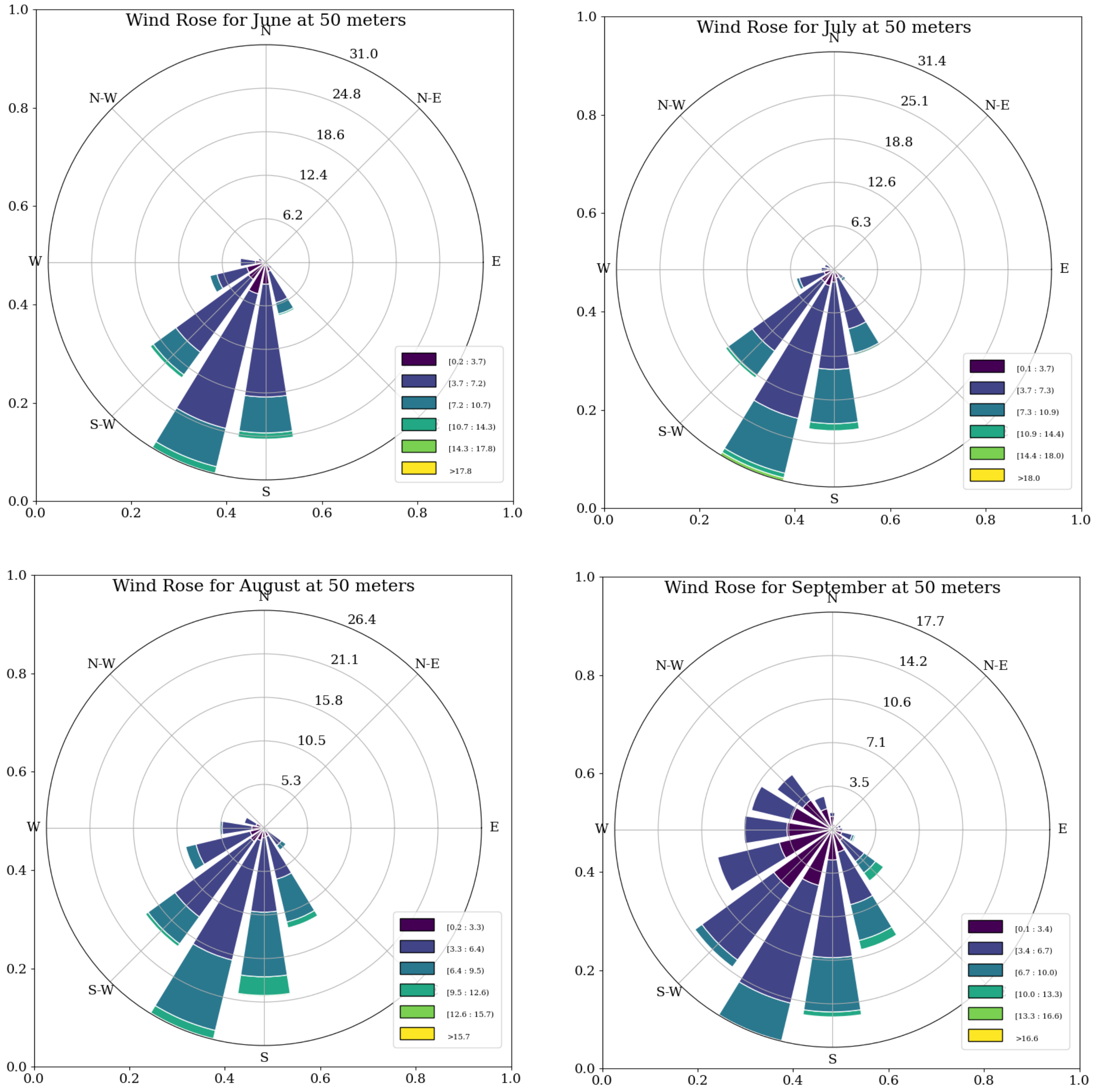


Figure 8: Wind Rose for Monsoon at 50 meters (June, July, August, September)

The wind rose graphs for the monsoon season (June to September) at 10 meters show dominant westerly (W) and southwest (SW) winds. June and July peak with W winds at 30.9% and 31.3% frequencies and speeds of 5.9–14.4 ms^{-1}. August sees reduced W winds (26.1%) with speeds of 5.2–12.8 ms^{-1}, while September shows further decline (17.5%) with speeds of 2.7–10.3 ms^{-1}. Westerly alignment is crucial for maximizing energy during the productive June and July months (Figure 9).

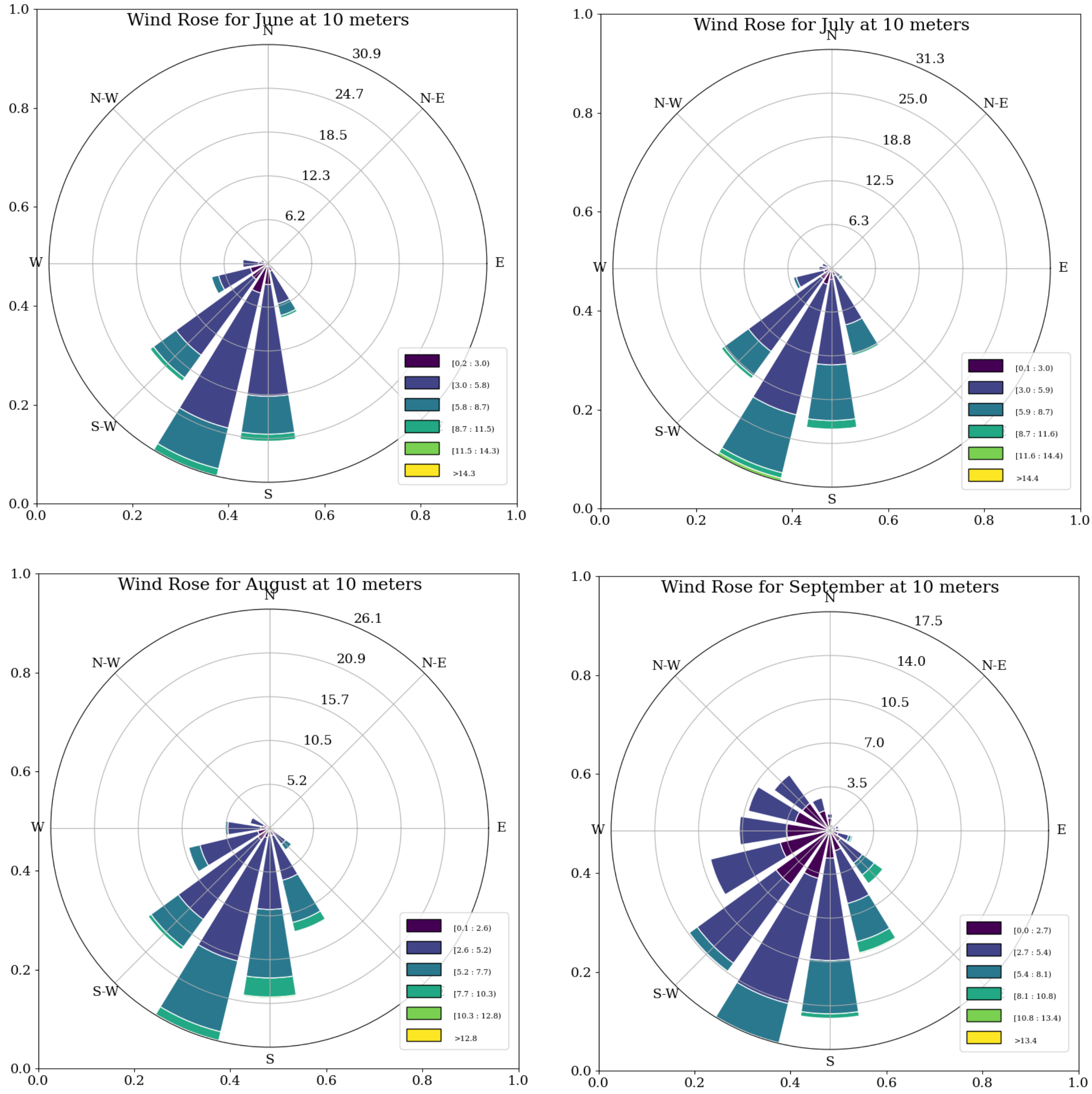


Figure 9: Wind Rose for Monsoon at 10 meters (June, July, August, September)

Autumn

The wind rose graphs for the autumn season (Figure 10), month of October and November, at 50 meters, depict very distinct wind patterns. During October, the dominating winds are westerly (W) with moderate speeds of 3.9–11.6 ms^{-1}, which is an indication of reduced energy potential compared to the monsoon. In November, the winds were dominated by NW winds at a frequency of 32%, while most of the speeds were lying within the range of 2.3–6.6 ms^{-1}, showing a more serene state of the atmosphere during the winter months. The changeover from W to NW winds suggests weakening wind from a seasonal perspective, although November has been weaker compared to October from an energy generation standpoint.

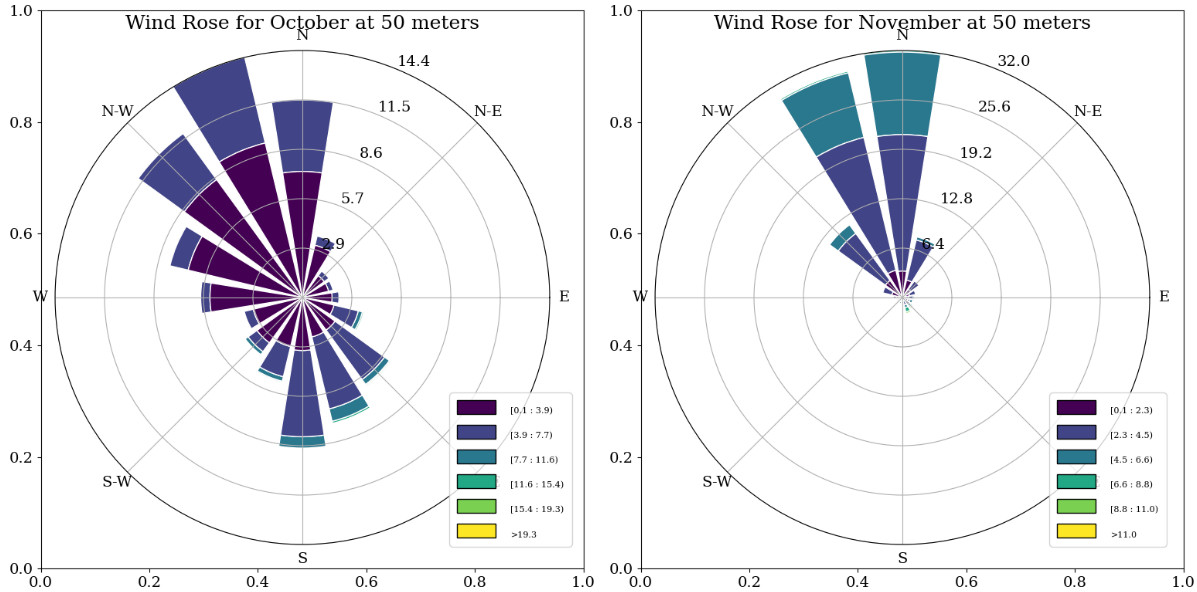


Figure 10: Wind Rose for Autumn at 50 meters (October, November)

The wind rose graphs (Figure 11) for autumn, represented by October and November at 10 meters, give a clear indication of the seasonal wind pattern. In October, the dominating winds are westerly directions with wind speeds between 3.2–12.5 ms^{-1}, thus offering moderate energy potential. In November, northwest winds take precedence with a frequency of 31.8%, with the predominant wind speed lying in the range of 1.8–5.5 ms^{-1}, which indicates that the wind has drastically weakened. This shift from W to NW winds is an expression of the fall wind energy decline, but October would still be more favorable for turbine operations.

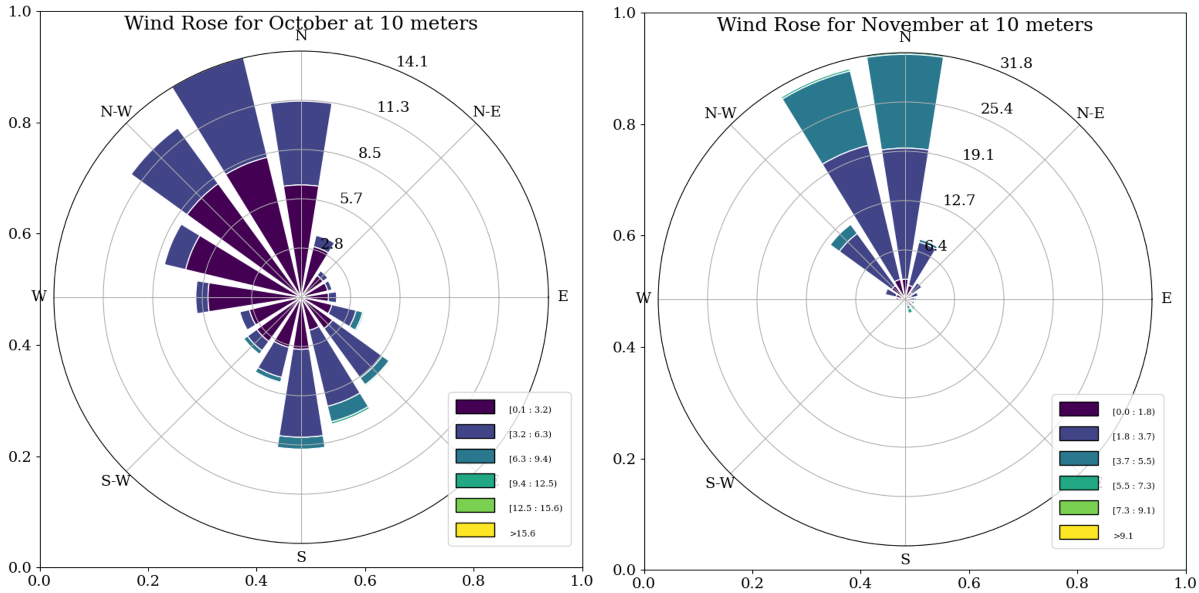


Figure 11: Wind Rose for Autumn at 10 meters (October, November)

Table 1: Seasonal Wind Characteristics and Energy Potential at 10m and 50m Heights

Season	Average Wind Speed (10m)	Direction (10m)	Average Wind Speed (50m)	Direction (50m)	Energy Potential
Autumn	3.01 ms^{-1}	233.26°	3.55 ms^{-1}	231.93°	Moderate; least productive season
Monsoon	4.52 ms^{-1}	205.49°	5.49 ms^{-1}	205.43°	Highest energy potential
Summer	3.44 ms^{-1}	259.02°	4.07 ms^{-1}	259.35°	Moderate; stable production
Winter	3.66 ms^{-1}	277.90°	4.31 ms^{-1}	276.65°	Stable; productive season

3.1.2 Diurnal and Monthly Variations (From Contour Plots):

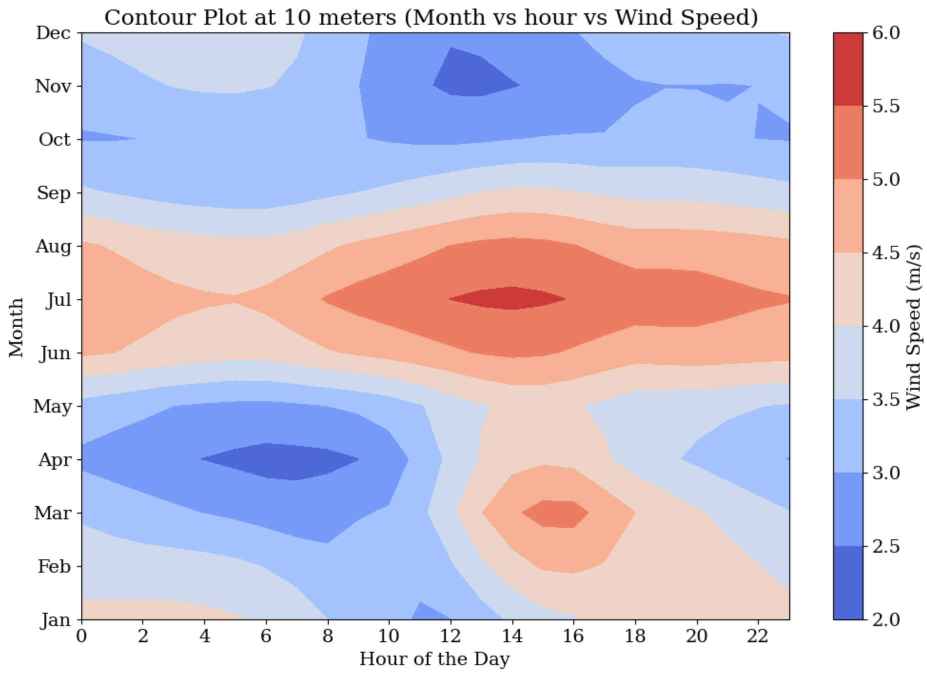


Figure 12: Contour Plot at 10 meters (Wind speed, Month, Hour)

This contour plot of Figure 12 shows the diurnal and monthly variations of the wind at 10 meters. It shows that during the months of June, July, and August, the wind speeds are far greater than any other month, remaining above 5.0 ms^{-1} in late afternoon and early evening hours, which is driven by increased atmospheric mixing and monsoonal influence. Contrarily, winds are weakest during the winter months of the year from January to March the wind speed is much below 3.0 ms^{-1} in the greater part of the day, with the lowest in early morning hours from 02:00 to 06:00. The diurnal variation indicates that it generally reaches its peak in the afternoon and falls during nighttime and early mornings along the year. This clearly shows the temporal pattern. Hence, turbines should be synchronized to maximize the use of higher wind speeds during peak hours for improved energy efficiency.

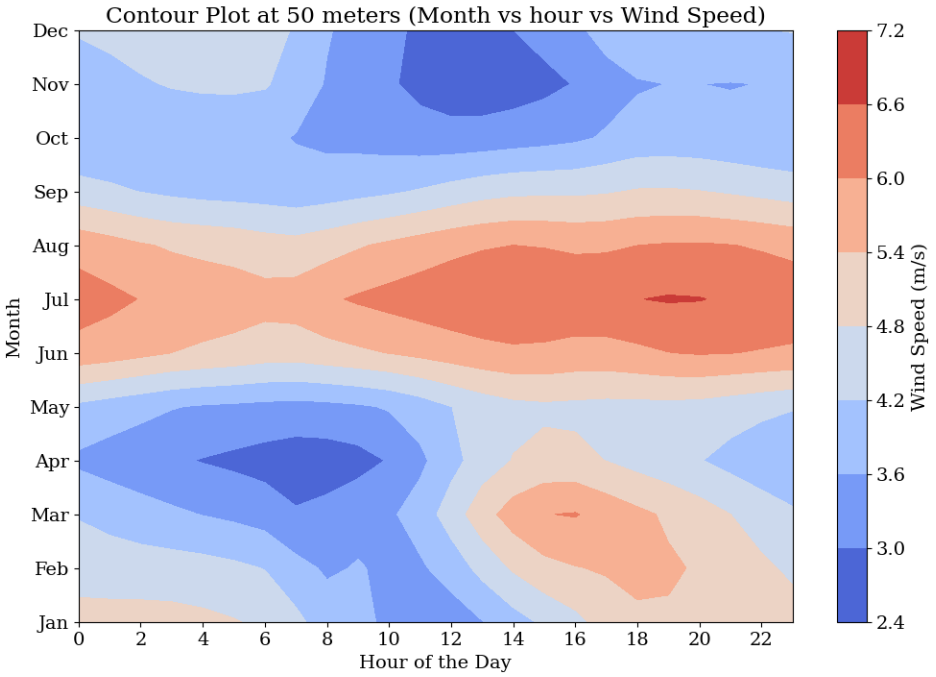


Figure 13: Contour Plot at 50 meters (Wind speed, Month, Hour)

The contour plot at 50 meters of Figure 13 highlights higher wind speeds during the monsoon months (June to August), peaking at 7.2 ms^{-1} in the late afternoon (16:00–18:00). In contrast, wind speeds are lowest during winter (January to March), averaging 2.4–4.0 ms^{-1}, with early mornings (02:00–06:00) showing the least activity.

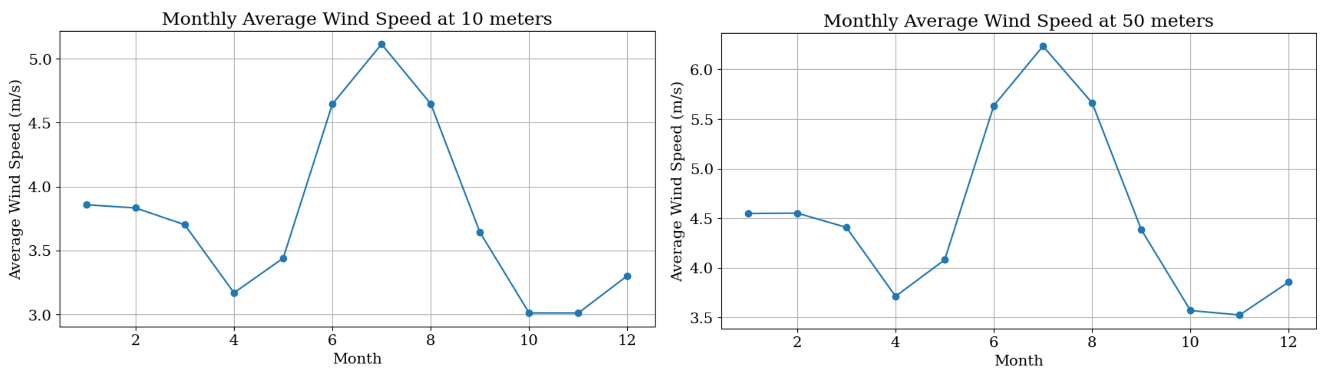


Figure 14: Monthly Average Wind Speed Variation at 10 and 50 meters.

At 10 meters, wind speeds range from a minimum of 3.5 ms^{-1} in October and November to a maximum of 5.2 ms^{-1} in July, with an average of 3.782 ms^{-1} sufficient to operate wind turbines. At 50 meters, speeds range from 3.55 ms^{-1} in November to 6.35 ms^{-1} in July, with an average of 4.515 ms^{-1}. These are shown in Figure 14 and Table 2.

Table 2: Comparison of Wind Characteristics at 10 Meters and 50 Meters Heights

Parameter	10 Meters	50 Meters
Peak Wind Speed (Season)	~5.5 ms^{-1} during monsoon (June, July, August)	~7.2 ms^{-1} during monsoon (June, July, August)
Lowest Wind Speed (Season)	~2.4 ms^{-1} during winter (January, February, March)	~3.0 ms^{-1} during winter (January, February, March)
Diurnal Peak (Time of Day)	Late afternoon (16:00–18:00)	Late afternoon (16:00–18:00)
Diurnal Lowest (Time of Day)	Early morning (02:00–06:00)	Early morning (02:00–06:00)
Seasonal Trend	Wind speed peaks during monsoon, decreases in winter	Wind speed peaks during monsoon, decreases in winter
Consistency	More variable across months and hours	More consistent across months and hours
Magnitude of Wind Speeds	Generally lower across all seasons and hours	Higher wind speeds due to reduced surface friction
Energy Potential	Moderate	High

3.2 Cyclone Path Analysis:

Typically, cyclones originate in the south of the Bay of Bengal and move upwards to Saint Martin. Amphan in 2020, Bulbul in 2019, and Sidr in 2007 are a few examples (Figures 15 & 16). Cyclones can form in the center of the Bay of Bengal, and they move to the west, but it is not so common. Nargis in 2008 [14], Alia in 2009 [15] and Amphan [16] are such examples whereas cyclone Mora moved from north-northeastward to northeast ward [17]. The cyclone's effect is more on the north side than the eastward side, and the eastward side faces indirect impacts from cyclones passing nearby, bringing with it winds, storm surge, and rainfall.

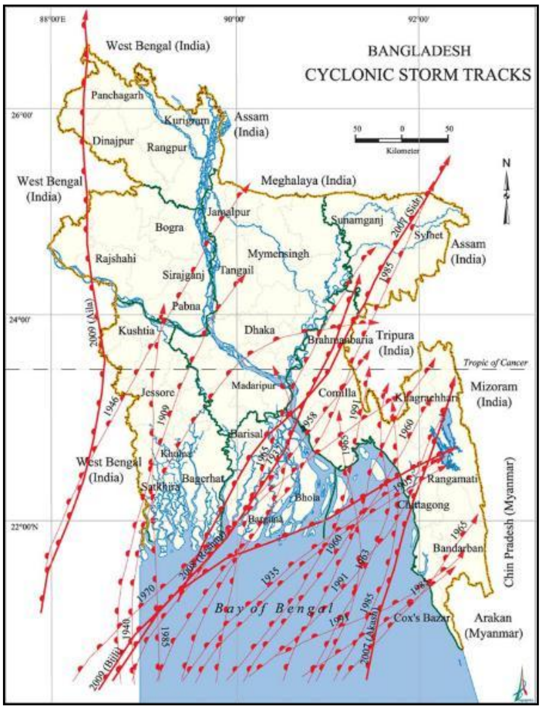
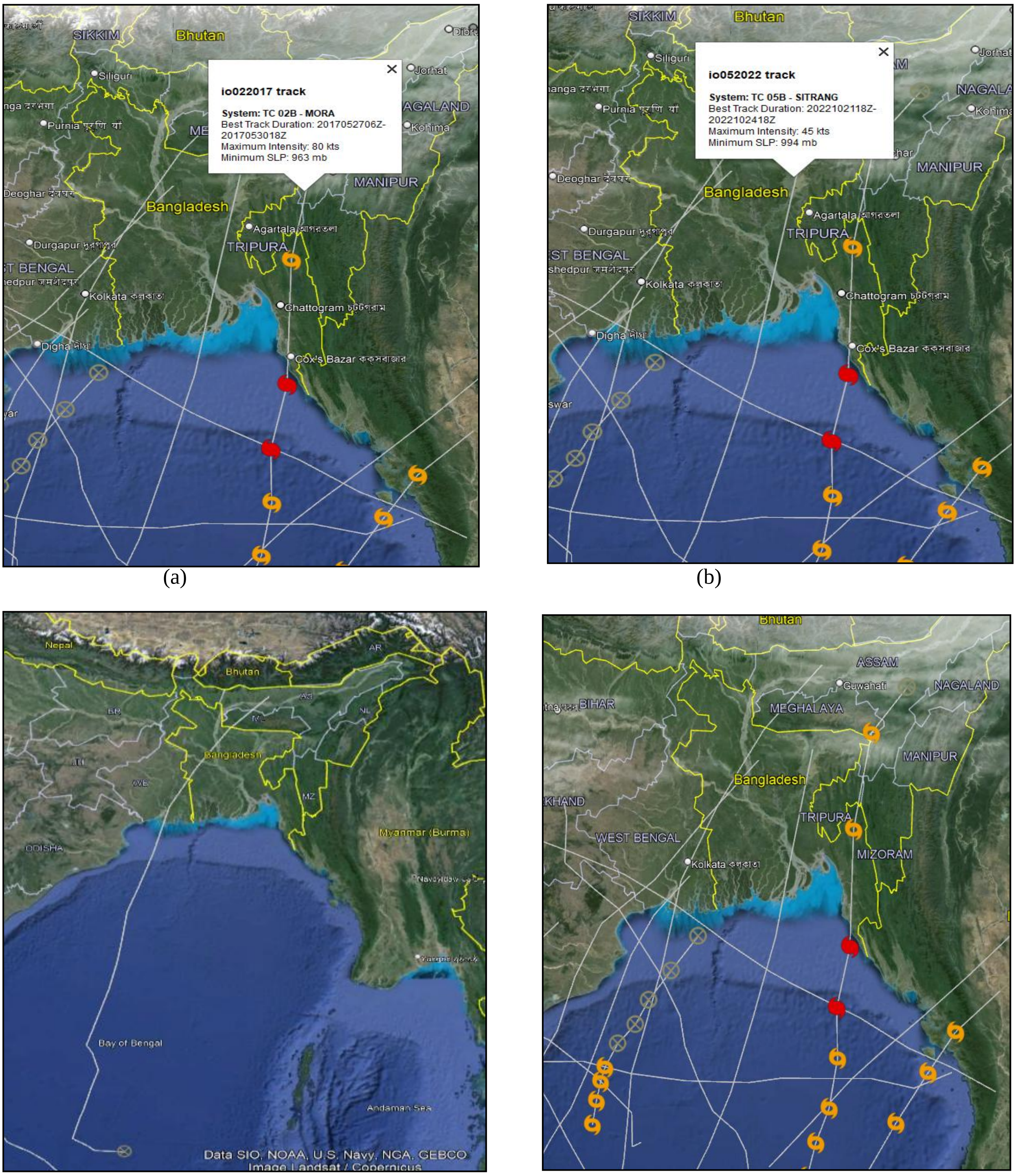


Figure 15: Cyclone Paths from year 1984 to 2014 [18]

Cyclones derive energy from the warm, moist air over the ocean [19]. On land, cyclones lose structural strength due to the absence of moisture and heat, therefore wind speed slows down. In contrast, over the sea, with plenty of heat and moisture, the cyclone replenishes its energy, and its wind speed will be maintained or even increased.



(a) (b) (c) (d)

Figure 16: a) Mora, b) Sitrang, c) Amphan. d) All remaining up to 2022 [20]

So, a suitable place should be selected considering the risk of cyclones. The region near Saint Martin is a promising option due to its cyclone path characteristics. Additionally, selecting the area behind Saint Martin could be a good option as the place should face the reduced power of cyclones.

As there is a border between Bangladesh and the neighboring country Myanmar in that region, the border must be identified correctly. From the ITLOS law of 2012, eight coordinates are collected to define the border [21] and placed in Google Maps (Figure 17).

166. For the above mentioned reasons, the Tribunal decides that the equidistance line delimiting the territorial sea between the two Parties is defined by points 1, 2, 3, 4, 5, 6, 7 and 8 with the following coordinates and connected by geodetic lines:

1: 20° 42' 15.8" N, 92°22' 07.2" E;
2: 20° 40' 45.0" N, 92°20' 29.0" E;
3: 20° 39' 51.0" N, 92° 21' 11.5" E;
4: 20° 37' 13.5" N, 92° 23' 42.3" E;
5: 20° 35' 26.7" N, 92° 24' 58.5" E;
6: 20° 33' 17.8" N, 92° 25' 46.0" E;
7: 20° 26' 11.3" N, 92° 24' 52.4" E;
8: 20° 22' 46.1" N, 92° 24' 09.1" E.

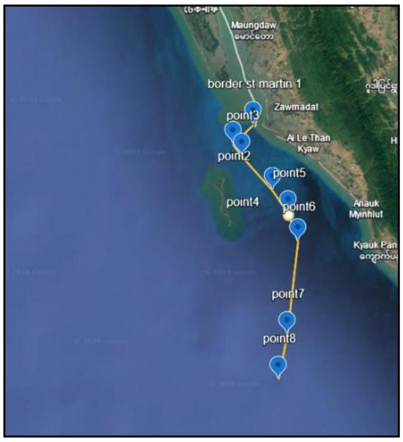


Figure 17: a) Coordinates of Sea Border, b) Border in Google Maps.

3.3 Depth

Depending on water depth, there are three types of foundations, such as:

1. Shallow Water Foundation
2. Transitional Water Foundation
3. Deep Water Foundation

If the depth range is from 0 to 30 m, then it needs a shallow water foundation.

If the range is from 30 to 60 m, then need a transitional water foundation.

But, when the range is from 60 m to 900 m, then it is under a deep-water foundation [22].

A floating platform is necessary for deep water, but it is a very expensive process.

The selected area in this research for an offshore wind farm has a water depth of 2-10 m shown in figure 18 [23], so it lies within the range of shallow water foundation.

The location and bathymetric data are shown in Figure 18.

Figure 18: Bathymetric Data of the place

4. CONCLUSIONS

The potential of offshore wind farms in Bangladesh is evaluated by this study, focusing on Saint Martin Island. Choosing the proper place is critical and depends on various environmental and technical factors. From the current study, the following conclusions can be drawn.

1. The cut-in speed for the wind turbine is about 2.5 to 3 ms^{-1}. Analysis of monthly wind speed variation for 50 meters and 10 meters heights, it is shown that the island has an average wind speed of 4.515 ms^{-1} at 50 meters height and 3.782 ms^{-1} at 10 meters height, respectively, making it a viable location.
2. Seasonal variations indicate higher wind speeds in June, July, and August, with a peak in July, while lower wind speeds occur at the beginning and end of the year. And diurnal variations show that wind speeds are lower in the early morning and higher in the late afternoon and early evening, identifying the optimal times for energy generation.
3. If the cyclone passes over St. Martin's Island, the wind will be slowed down; thus, it will affect the wind farm placed at the back of the island less strongly. This natural shielding effect gives the area behind Saint Martin a privileged place for cutting risks originating from cyclones.
4. The analysis of cyclone paths shows that the east side of the island is safer and less vulnerable to natural disasters. This helps to keep the wind farm stable for a long time, lowering maintenance costs.
5. Water depth is a critical factor in wind farm location selection and design. The analysis indicates that at this location, the water depth is suitable for shallow water foundation which is cost effective and more efficient than floating platforms.

More work needs to be done to consider seabed conditions and tidal bore effects. Based on statistics and presented analysis, the potential offshore wind farm project stands valid in the development context of Saint Martin. Integration through advanced analytical methodologies and environmental dataset information builds stronger conditions toward renewable venture development in these areas to enable the contribution of sustainable energy initiatives in Bangladesh.

5. ACKNOWLEDGEMENT

This research was supported by the *RISE Undergraduate Student Research Grant*, awarded to final-year undergraduate students at the Bangladesh University of Engineering and Technology (BUET) following a proposal submission and selection process. The authors sincerely thank BUET and the RISE program for their financial and institutional support, which made this study possible.

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