

Characteristics of Winds and Evaluation of Typhoon Wind Reduction by Pandanus Trees on Saint Martin's Island, Bangladesh

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Abstract - Bangladesh is a small developing country in South Asia with a densely populated crisis and is prone to several natural hazards. Due to climate change, the frequency of devastating events increasing. Coastal low-lying poor people are the worst victim of severe cyclones. Saint Martin's Island is a tiny island located in Bangladesh that is rich in biodiversity but threatened by many natural disasters, and it is often neglected due to being far from the mainland. Ecosystem-based Disaster Risk Reduction (Eco-DRR) is the most urgently required provision for Bangladesh as it is a very easy and inexpensive way to survive natural adversities. In this study, attempts have been taken to quantify the capacity of an existing Pandanus Forest on Saint Martin's Island to reduce the storm surge disaster risk. For this, historical data were collected and processed with ArcGIS software, and mean wind speed and cyclonic average wind were analyzed to determine the reduction of wind speed by Pandanus trees. Average storm wind speed was analyzed using the IDW interpolation method. The results showed that the average wind speed faced during a cyclone was 11-15 km/hrs and Pandanus trees can reduce the wind speed by almost 52%, which ultimately protect the island and helped the wind speed range around 7 km/hrs.

Keywords: cyclones, wind speed, wind direction, wind speed reduction

1. Introduction

Bangladesh lies in the range of cyclone turbulence zone, the country, in general, is considered a cyclone-prone area [1]. According to the current statistics, an average of 1.15 tropical cyclones hit Bangladesh each year. The climate change scenario has triggered extreme events. Thus, the frequency of devastating cyclones on the Bangladesh coast is increasing over the decades. Ecosystem-based disaster risk reduction (Eco-DRR) possibly be the best option for Bangladesh to cope with the disasters. The purpose of this study is to evaluate the wind characteristics and cyclonic wind speed and direction on St. Martin Island, Bangladesh, and to assess the reduction of cyclonic wind speed by pandanus trees on that island.

2. Study Area Description

Saint Martin's Island is tiny, with an area of 3.4 km², and it is situated within the southernmost region of Bangladesh (Fig. 1). The length and width are, respectively, 1524 m and 518 m. The island is situated in the Bay of Bengal, about 9 km south of the Cox's Bazar-Teknaf peninsula and northwest of the Myanmar coast, and at the mouth of the Naf River. The longitudes of the island are 92°18'E and 92°21'E and the latitudes are 20°34' and 20°39'N [2]. The most dominant plant on the island is Screw pine, also known as the Umbrella tree or Pandanus (locally called Keya). The existing Pandanus trees were developed as a defensive shield surrounding the island [3].

3. Methods

3.1. Evaluate the mean wind speed on an average day on the island.

Wind speed data was collected from the Global Wind Atlas website. The data was prepared in ArcGIS to extract the mean speed of Bangladesh and the study area as well. The mean wind speed map was prepared according to the data.

3.2 Calculate the Average Wind Speed and Direction during the cyclone in the study area.

Around 153 tropical cyclones made landfall in the vicinity of Saint Martin's Island (Fig. 2) between 1877 and 2020 (EM-DAT). This analysis was performed using the available data sources (BMD, EM-DAT, IBtracks V4.0 database), and the frequency and return period were computed with the popular Weibull formula. The study area was considered the most vulnerable to the highest maximum wind speeds of cyclones [4]. The data was analyzed in ArcGIS10.5 software. In order to find out the wind speed and direction in the area during a cyclone, the Inverse Distance Weighted (IDW) interpolation method was applied. The formula was as follows-

$$X_p = \frac{\sum_{i=1}^n (X_i / D_i^p)}{\sum_{i=1}^n (1 / D_i^p)}$$
 where X denotes the point of a specific location and D is the distance of the unknown points in respect of the known points.

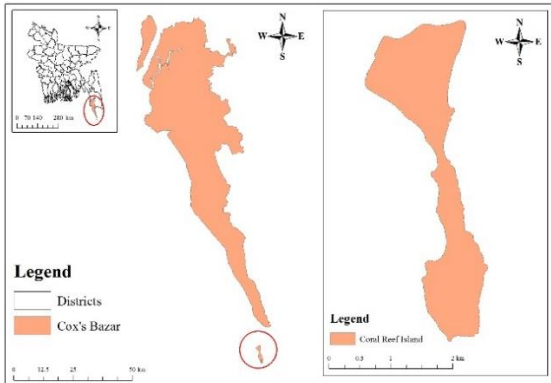


Fig. 1: Location of the study area

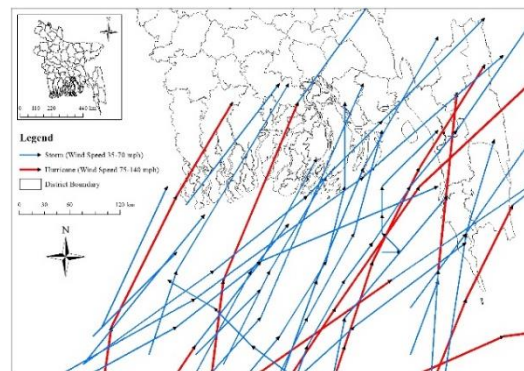


Fig. 2: Historical hurricane and cyclone tracks (1973-2017)

Table 1: Cyclone-induced damages in Bangladesh.

Cyclone damages at a glance in Bangladesh (1990-2020)	
Total Deaths	145962
No Injured	257255
No Homeless	1713825
Total Affected	43868264
Total Damages ('000 US\$)	6623285

3.3 Evaluate the Wind Speed Reduction by Pandanus trees on the island.

Ferrario et al. stated that trees can reduce 59.4% the mean wind speed during a cyclone [5]. Following that finding, the wind speed reduction was calculated. The reduced wind speed was plotted in ArcGIS and the map with reduced wind speed was prepared. In order to determine the distribution of Pandanus trees, a GPS survey was performed and plotted on a map. In this way, the tree density and distribution were found for the year 2021 (Fig. 3). In order to represent canopy cover changes over time, NDVI indices maps (Fig. 4) were prepared using the ArcGIS software.

4. Results

4.1 Mean Wind Speed

It was found that the mean wind speed of the study area was about 3.66 to 4.35 km/hr. the study area possessed considerably high wind on regular days in respect of the other places of the country (Fig. 5).

4.2 Wind Speed and Direction during the Cyclone

Analysis results showed that the study area was affected by the wind speed of 11-20 km/hr during the cyclone (Fig. 6). The wind speed was considered very high as the study area has no barrier except the pandanus trees and is very tiny in shape.

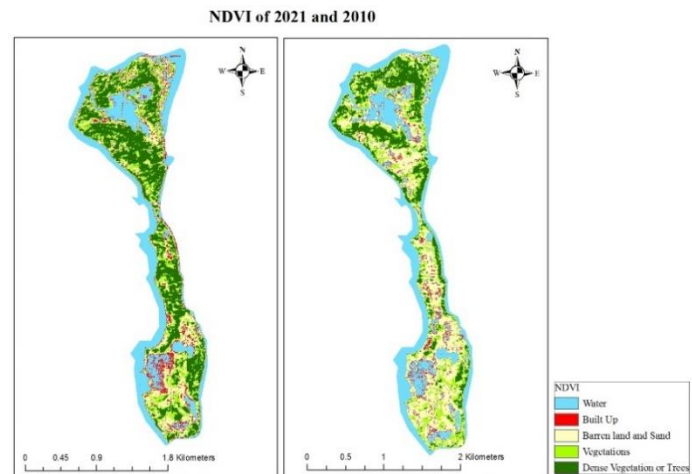
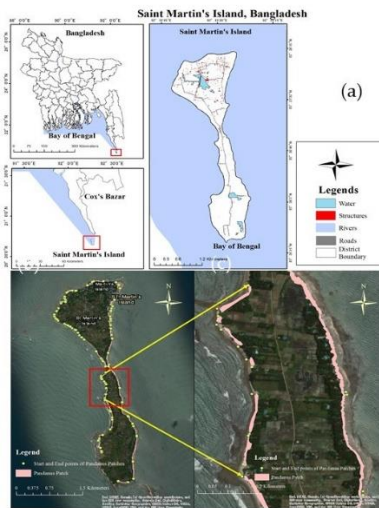


Fig. 3: Evaluation of Pandanus trees in Saint Martin's Island Bangladesh[6]. Fig. 4 NDVI index of the study area

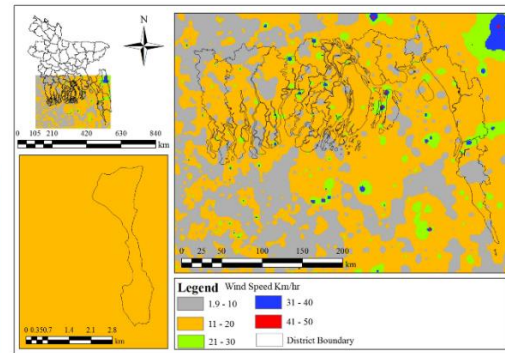
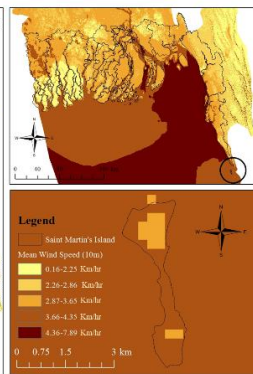
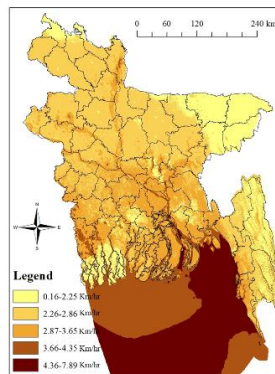


Fig. 5: Mean wind speed of the study area

Fig. 6: Mean wind speed during a cyclone in the study area

The wind direction in the coastal areas of Bangladesh and wind direction in the study area revealed that the direction was mostly from the north-western side (Fig. 7). The study area is so small and being an open island, it faces wind from different directions. The upper part of the island is mostly affected by the south-eastern side, the middle part is affected by wind from the eastern side and the lower part is affected by north-eastern wind (Fig. 8).

4.3 Wind Speed Reduction by Pandanus Forest

The results show that the Pandanus Forest reduced the wind speed in the inner areas of the island (Fig. 9). While the boundary of the island faces high wind of almost 11-20 km/hr, the inside of the island faces wind speed of 6-8 km/hr (Fig. 10).

5. Discussion

In respect of an average day, the wind speed of the study area was found to be high as it is an open sea island and there seems no barrier to the island except the Pandanus tree barriers. The wind direction of the study area was found to be scattered and the different parts of the island were affected by wind from different directions. The boundary layer of Pandanus Forest

resists the wind and saves the area from being very strong in the central area of the island. The geomorphological characteristics of the region have made the study area prone to major tropical cyclone events, events that have occurred multiple times in the past, directly causing loss of lives, property, livelihoods, and the economy of the country and slowing down the process of development. Eco-DRR is a very popular and established method in the developed world. The Bangladesh government should consider this concept to utilize the existing Eco-DRR and promote the concept for the future welfare of the country against the DRR.

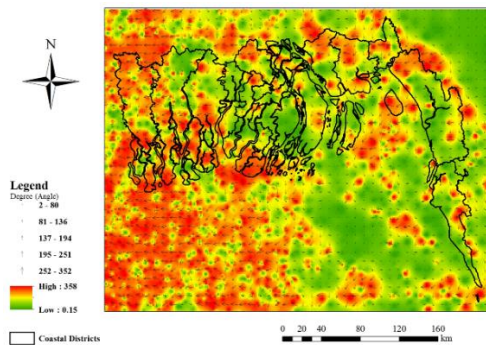


Fig. 7: Wind direction map of the study area

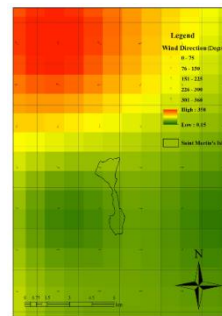


Fig. 8: Wind direction during a cyclone in the study area

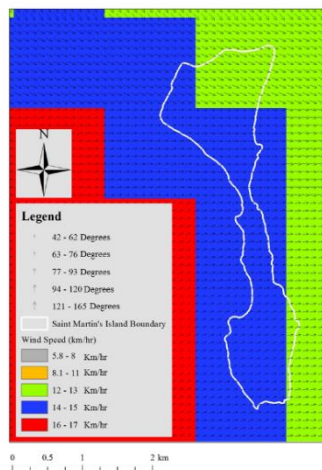


Fig. 9: Cyclone wind Speed and direction in the study area

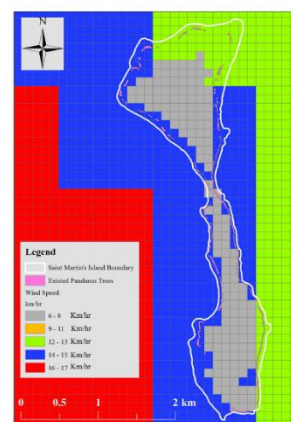


Fig. 10: Cyclone wind speed inside the study area

6. Conclusion

In this study, attempts have been taken to quantify the capacity of an existing Pandanus Forest on Saint Martin's Island to reduce the storm surge disaster risk. For this, historical data were collected and processed with ArcGIS software, and mean wind speed and cyclonic average wind were analyzed to determine the reduction of wind speed by Pandanus trees. Average storm wind speed was analyzed using the IDW interpolation method. The results showed that the average wind speed faced during a cyclone was 11-15 km/hrs and Pandanus trees can reduce the wind speed by almost 52%, which ultimately protect the island and helped the wind speed range around 7 km/hrs.

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