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The current cyclone early warning system in Bangladesh: Providers' and receivers' views

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ABSTRACT

Bangladesh has experienced several catastrophic Tropical Cyclones (TCs) during the last decades. Despite the efforts of disaster management organizations, as well as the Bangladesh Meteorological Department (BMD), there were lapses in the residents' evacuation behavior. To examine the processes of TC forecasting and warning at BMD and to understand the reasons for residents' reluctance to evacuate after a cyclone warning, we conducted an individual in-depth interview among the meteorologists at BMD, as well as a questionnaire survey among the residents living in the coastal areas. The results reveal that the forecasts produced by BMD are not reliable for longer than 12-h. Therefore, longer-term warnings have to be based on gross estimates of TC intensity and motion, which renders the disseminated warning messages unreliable. Our results indicate that residents in the coastal areas studied, do not follow the evacuation orders due to mistrust of the warning messages—which can deter from early evacuation; and insufficient number of shelters and poor transportation possibilities—which discourages late evacuation. Suggestions made by the residents highlight the necessity of improved warning messages in the future. These findings indicate the need for improved forecasting, and more reliable and more informative warning messages for ensuring a timely evacuation response from residents.

1. Introduction

Bangladesh is one of the most vulnerable countries for Tropical Cyclone (TC) induced disasters. Fourteen of the nineteen coastal districts of Bangladesh are high or moderate cyclone-risk areas [1,2]. These exposed districts are currently the home of around thirty and a half million people [3]. To ensure the safety of residents in the coastal areas, the Bangladesh government is investing considerable effort into developing a suitable approach to manage cyclone emergencies [4]. As a result, residents' response to evacuation orders has improved considerably during the last decades [5–7]. Although residents' current evacuation response rate is still not satisfactory, further improvements could be difficult to achieve without resolving technical issues associated with early warnings as well as infrastructural problems (improved cyclone shelters, road communication, and housing) [5,8–10].

The success of an early warning system depends both on technical processes that turn meteorological data into warnings, and on human factors that transform warnings into actions [11–14]. In this article, we look at the cyclone early warning system in Bangladesh from two complementary perspectives:

1. How the Bangladesh Meteorological Department (BMD) forecasts TCs and disseminates warning messages.
2. How the residents in affected areas tend to react to warnings and evacuation orders.

Hence, we have collected data both from meteorologists at BMD and from residents in two coastal districts of Bangladesh, namely Bagerhat and Patuakhali, where the latter is a high cyclone-risk area and the former is a moderate-risk area, according to the cyclone-risk area classification proposed by Khan, Bhuyan, and Rahman [1].

2. Background

The Storm Warning Center (SWC) is a specialized unit of BMD, and is responsible for forecasting and issuing warnings for TCs in Bangladesh. BMD collects meteorological data through 35 ground-based, 10 weather balloon, 5 radar, and 3 rawinsonde stations. In addition, BMD receives weather satellite data, ocean-buoy-recorded meteorological, and sea surface data, and numerical-

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model-generated weather forecasts from other national and regional meteorological offices, as a member state of the World Meteorological Organization [15–17]. Currently, BMD employs two techniques: (a) Storm Track Prediction (STP), and (b) Steering and Persistence (STEEPER) for TC forecasting [18,19]. Technically, neither STP nor STEEPER is sufficiently advanced, and therefore cannot produce forecasts with good accuracy for more than 12 h ahead [19].

2.1. TC warning stages

Low-pressure systems usually form deep south in the Bay of Bengal (BoB) between 5° and 15° north latitudes, outside the coverage of radar [20,21]. To compensate for this, meteorologists at BMD use satellite images to monitor low-pressure systems over the bay. When a low-pressure system initially intensifies and sets a course towards north, meteorologists forecast its motion and intensity and issue an initial warning message. Through the issuance of the first warning, a Standing Order for Disaster (SOD) is initiated. The SOD provides guidelines for all the government agencies about the required state of readiness for responding to a probable TC attack [22,23]. After formation, TCs in the bay initially tend to move towards west or north-west and then set course towards north or north-east to finally make a landfall [24]. Due to this movement pattern, TCs frequently make landfall at the mid and east coast of Bangladesh.

Cyclone alert stage—This first stage is initiated at least 36 h before a predicted landfall, when the speed of the rotating wind within a TC reaches 50 km/h [24]. At this stage, BMD issues a *cyclone alert message* and informs the maritime ports, the river ports, and the media about the approaching TC. BMD also sends warning messages directly to the national coordination committee, the cyclone preparedness program, the relief and rehabilitation authorities and to the local administrations [15,24].

Cyclone warning stage—This second stage is initiated at least 24 h before a predicted landfall, when wind speeds get between 51 km/h and 61 km/h. A *cyclone warning message* is sent to the respective authorities and media, containing information about: (a) the current and forecasted position of the TC, (b) the TCs movement direction and rate of movement, (c) maritime ports and areas likely to be hit, (d) current maximum wind speed, (e) forecasted height of the storm surge, and (f) suggested safety measures for fishing boats [18].

Cyclone disaster stage—This stage is initiated at least 18 h before landfall. If the maximum wind speed within the TC exceeds 61 km/h, a *cyclone danger warning* is issued, and an updated danger-warning message is disseminated every 30 min.

Cyclone great-danger stage—This last stage is initiated at least 10 h before the predicted landfall. If the wind speed exceeds 89 km/h, a cyclone *great-danger warning message* is issued and the residents are urged to evacuate at this point [25]. Updates to a great-danger warning message are usually disseminated every 15 min.

BMD uses two separate signaling systems for the maritime and the river ports (and respective command areas) to convey the danger levels associated with TCs. An eleven-point signaling system, ranging from low to high danger level, is used for the maritime ports. In contrast, a four-point signaling system, ranging from low and high danger levels, is used for the river ports. In a warning message, the coastal districts located to the west of the Meghna estuary lie in the command area of *Mongla* maritime port, while the districts located to the east lie in the command area of *Chittagong* maritime port (Fig. 1).

2.1.1. New methods for warning message dissemination

The Bangladesh Department of Disaster Management (DDM) has recently developed three mobile-network-based warning message dissemination methods in order to make warning messages easily accessible to the coastal residents and field-level disaster management committees [22]:

1. *Cell Broadcasting System* can be used to send warning messages to a targeted population group that is, residents in the coastal areas.
2. *Interactive Voice Response* is a method where residents can listen to a recorded warning message by calling a number.
3. *Short Message Service* is a text messaging service, which is specially designed for field-level disaster management

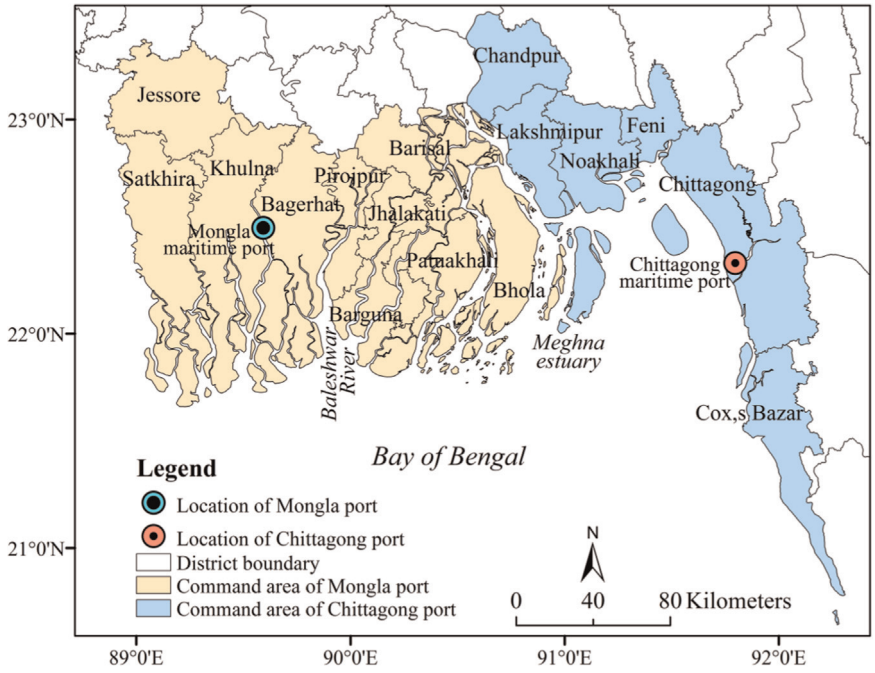

Fig. 1. Location of the maritime ports and their command areas.