Forecast based Financing

german humanitarian assistance

International Federation of Red Cross and Red Crescent Societies

German Red Cross

RED CROSS/RED CRESCENT CLIMATE CENTRE

Introduction

Extreme natural events like tropical storms and river floods hit Bangladesh time and again. Over the years many measures were successfully undertaken to reduce the risk of casualties and damages and especially the losses of life were reduced dramatically. However, with a growing population and rising sea levels a considerable (and probably increasing) part of the population lives in dangerous areas exposed to the forces of nature. Typically the poor and marginalized are forced to settle in such spots because they cannot afford to dwell in safer locations. They need to take protective actions like evacuation or stock up emergency supplies if a dangerous natural event is forecasted, but this is often beyond their means. In principle early warning systems include urgent actions to be taken if a warning is issued, but in reality this is normally limited to the dissemination of warning alert messages.The effectiveness of early warning could be enhanced if community level actions would be assisted more actively by the government and other actors. All actions cost money in one way or the other and this requires funds specifically for this purpose. In view of this the term Forecast based Financing was coined. It describes the process of implementing preparedness actions based on scientific forecasts of dangerous natural events.

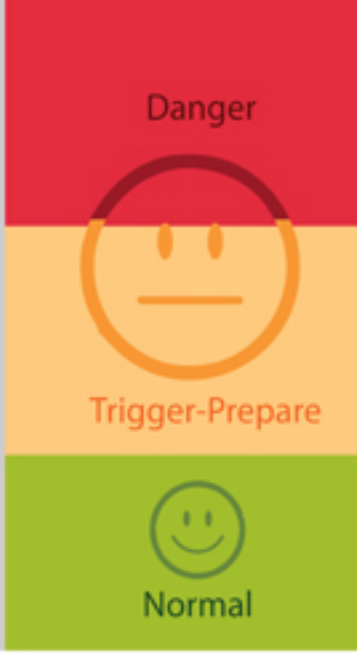
In Forecast based Financing two basic features are distinguished. The first describes the determination and production of a forecast, the second deals with the actions based on the forecast. The design and implementation of these actions are called Standard Operational Procedures (SOP). This booklet elaborates on the forecasts while another one handles the SOPs.The Bangladesh Red Crescent Society (BDRCS) and German Red Cross (GRC) are currently piloting this new Forecast based Financing approach in Bangladesh. GRC supports FbF also in Peru and Mozambique and other countries are expected to join soon. The testing is meant to demonstrate that FbF is reducing damages and losses and is more cost efficient than spending a lot of funds on response and rehabilitation. The current project phase is also expected to generate experiences which may be used for eventual replication and up scaling of FbF. The FBP pilot project is focusing on floods (Bogra district; 4 communities) and cyclones (Noakhali district; 4 communities), with activities from July 2015 to June 2017 and funding from the German Ministry of Foreign Affairs.

FbF aims at reducing this gap

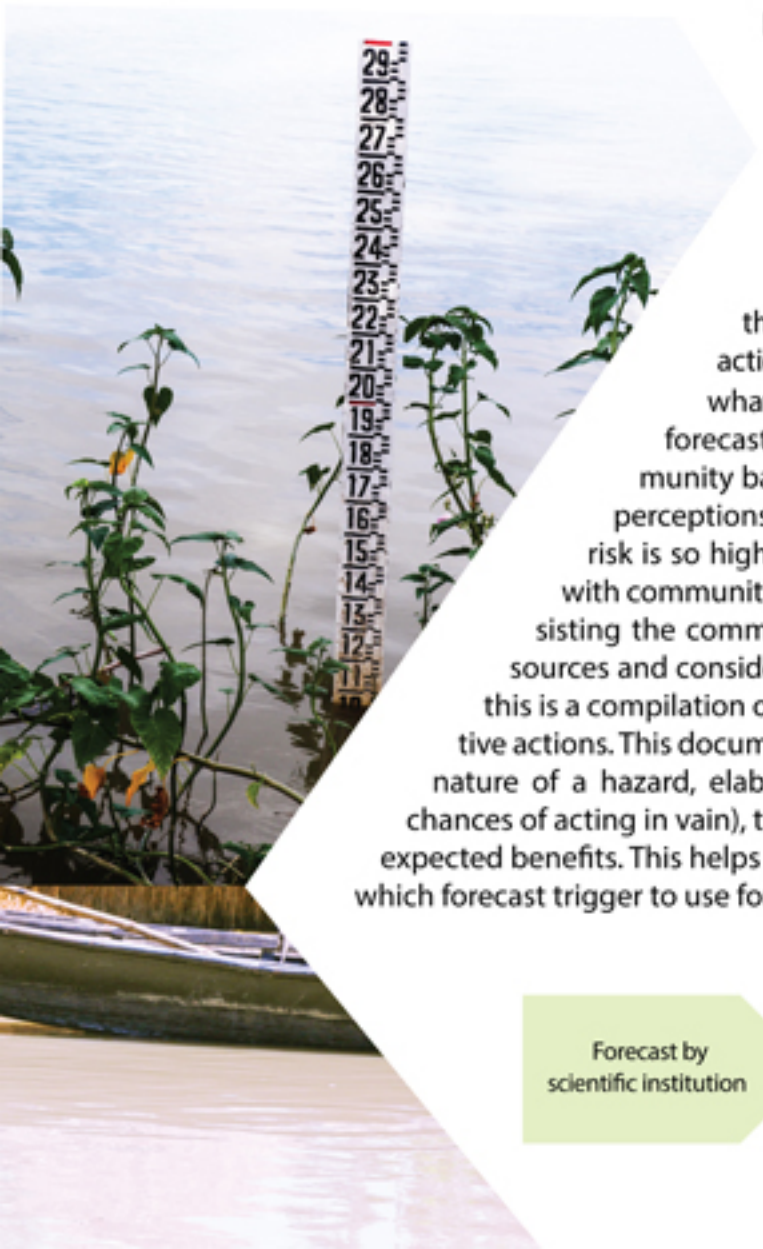
Few activities of governmental office, very little activities of other actors

Forecasts, Triggers and Danger Levels

A forecast is a prediction of a future event. In the context of FbF this refers to an extreme weather or geological event. The term trigger means a specific likelihood of reaching a threshold value which is used to initiate actions. This is also called danger level. For example a 60% chance of a cyclone with wind speeds of 112km/h hitting a town within two days could be a threshold value (danger level) used as a trigger for preparatory actions. Forecasts are usually produced by mandated scientific, governmental institutions like the Bangladesh Meteorological Department (BMD) or the Flood Forecasting and Warning Center (FFWC), while the determination of what action to take at what forecast depends on local communities and organisations like BDRCS and GRC supporting them.

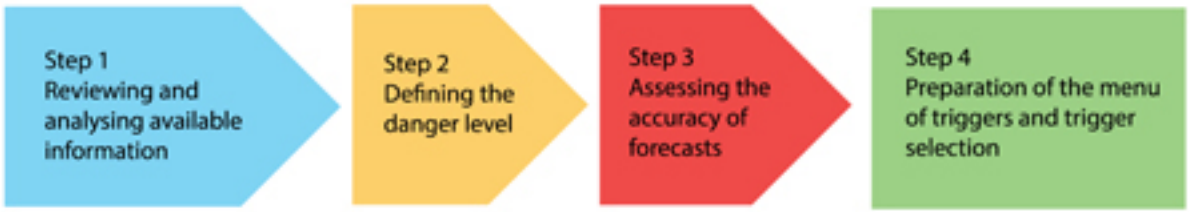


Setting up a Trigger



Forecasts provide information about the expected probability and the date and time of occurrence of an extreme event of a specific severity. Very often governmental nstitutions declare and disseminate warnings based on such forecasts. These warnings often come in different alert levels and accordingly different actions are prescribed (.g. evacuation). In the FbF context up to now only one alert level, the danger level, has been implemented, although it would be possible to carry out many different actions when different thresholds are reached. The decision what action to take when a specific danger level is forecasted should be based on available scientific and community based information. Different people may have different perceptions of what a dangerous development is and when the risk is so high that actions have to be taken. Therefore discussions with communities are important, however, outside organisations assisting the community also have to make economical use of their resources and consider how to use funds wisely. The best way to approach this is a compilation of different possible thresholds combined with respective actions. This document is called a menu of triggers and it is describing the nature of a hazard, elaborating on the accuracy of forecasts (including the chances of acting in vain), the practicability and costs of different actions and the expected benefits. This helps communities and disaster risk managers to select which forecast trigger to use for which preparedness action.

In the FbF context a four step mechanism is recommended for the development of a trigger for actions:



Step 1: Reviewing and Analyzing Available Information

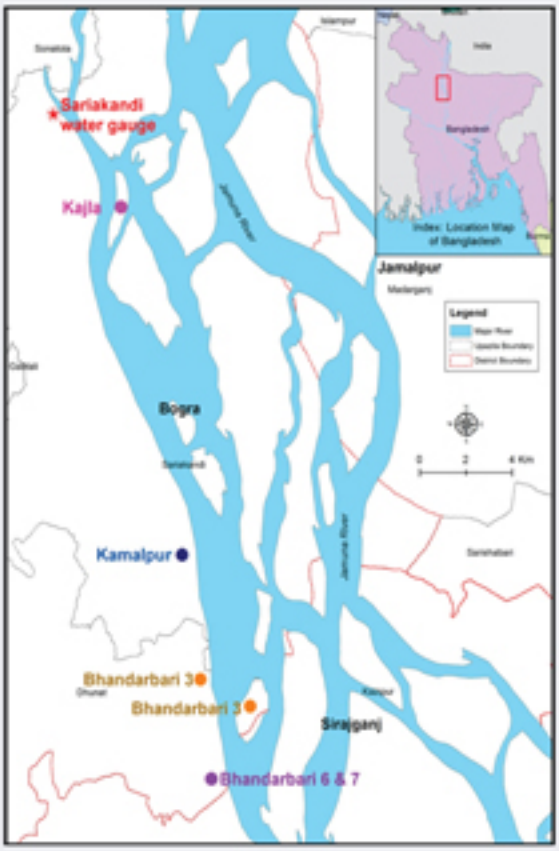
Forecast based Financing depends on the availability of reliable forecasts for a specific location and a specific hazard. In order to judge this information on available forecasts, early warning systems, historical records and risk assessments have to be considered. Usually FbF relies on the forecasts of mandated government offices producing forecasts, but such forecasts are not necessarily very reliable. The lack of reliability may be caused by the erratic nature of a hazard, or skills and equipment of the forecasting institution. Furthermore, some forecasts might not be accessible to the public or hard to understand for non-technical persons and thus they might not be suitable for FbF.All existing forecasts available for the selected hazards and target area at national, regional and global level have to be reviewed. The quality of the mandated forecasts needs to be verified by other sources.

Existing Government Forecasts in Bangladesh

Hazard	Available forecasts	Accessibility	Local expertise for utilizing forecasts and warnings
Floods	Covers more than 60% of the affected region. Up to 5 day deterministic forecast and up to 10-day probabilistic forecast available up to district level.	Free, web-based, updated twice daily.	Already in use at district levels by disaster management agencies, but some information requires translation to layman's language of forecasts for easy understanding.
Cyclones	72 hour rainfall forecast that is translated into 11ranges. Cyclone track and wind speed prediction in 10 alert levels. Storm surge flooding model not available.	Cyclone warning is available at all levels of administration. It is disseminated by SMS (etc.) by Department of Disaster Management and Bangladesh Meteorological Department	The 10 stage alert level system is a challenge even for disaster managers, but the simple 3 flags system is understandable and used at community level and by volunteers for preparedness actions.

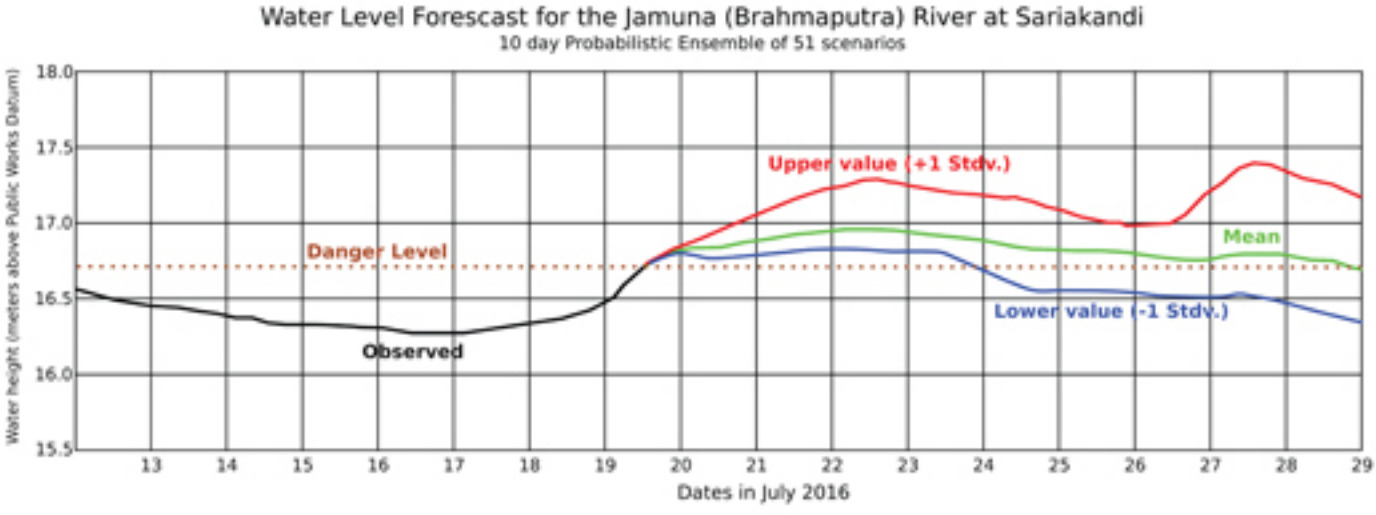
Flood Forecasting in Bangladesh

Flood forecasting in Bangladesh is done by the Flood Forecasting and Warning Centre (FFWC) under the Ministry of Water Resources. The FFWC uses both deterministic and probabilistic forecasts and they cover about 60% of the flood affected areas. This includes Bogra, one of the FbF pilot sites. The deterministic forecast is valid for5 days with high accuracy, while probabilistic model forecastsfor 10 days. The forecasts are using a danger level as a threshold and the value 50cm below the danger level and 1m above the danger level are used as markers, but they are not translated into clear public warnings and both, the deterministic and the probabilistic forecasts, are published side by side with differing data. The public can chose which data to use as a warning.



The governmental Shariakandi water gauge station is close to the FbF pilot sites in Bogra districts.

BDRCS/GRC asked community members to record the water height in their areas for three months. With these data it was possible to correlate the water height of Shariakandi with the water height in the four communities assisted by BDRCS/GRC. This means if a certain water level is forecasted for Shariakandi it is easy to calculate how high the water will be in the four communities.



Cyclone forecasting in Bangladesh

The Bangladesh Meteorological Department (BMD) is responsible for the official cyclone forecasts in the country. The forecasts are disseminated in the form of widely predicted path of the storm, the expe and other parameters. The warnings of BMD come in ten signal levels indicating expected conditions at some sea ports of the country.

BDRCS/GRC analyzed the BMD forecasts and noted the following observations:

- Signal 4. Wind speeds up to 61km/h are predicted for coastal ports. The time until landfall is 48 hours.
- Signal 5 to 7. The cyclone with wind speeds of 62 to 88km/h has a 50-60% chance to cross over the Bangladesh coast. The time until land fall is 18 to 48 hours.
- Signal 8 to10. The cyclone with wind speeds of more than 88km/h has a 70-80% chance to cross over the Bangladesh coast. The time until land fall is 12 to 24 hours.

The pilot sites of BDRCS/GRC are in the two upazilas of the Noakhali district and exposed to cyclones.

The cyclones crossing the Bangladesh coast and in particular Hatiya/Noakhalifrom 1891 to 2015 were analyzed based on historical data of the New Delhi based Regional Specialized Meteorological Centre. According to this source 89 cyclones with wind speeds of more than 62 km/h made landfall over Bangladesh in 124 years. Out of 89 cyclones 29 (32.6%) made landfall over or near Hatiya/Noakhali. This means statistically 2.3 cyclones hit the Hatiya/Noakhali area in 10 years. According to another source ten cyclones affected the Hatiya/Noakhali area from 1991 to 2016. This results in a statistical frequency of 4 storms in a period of 10 years.

Step 2: Defining the Danger Level

The danger level (DL) is the severity of an extreme event that will lead to an impact requiring actions by the affected population and/or governmental or other institutions. It is to some extent subjective to what degree an extreme event may be tolerated without any preparation. Different persons may have different perceptions on this and communication and discussions are recommended to find a commonly agreed danger level. As hazards have many different characteristics the danger level might also be defined by any of these characteristics.

For example floods are dangerous because of the water height, the duration the water remains high, current, floating debris, temperature, chemical and biological content. Usually a danger level is defined by just one feature, but it is also possible to combine two or more. For example, a water height expected to stay for three days combines two features. As danger levels depend a lot on risk perception they may also change over time and it is recommended to revisit them regularly.

It is also possible to define different danger levels for one area depending on different severities and thus different expected impacts on the same asset or on different assets (e.g. residential houses, agriculture). However, to keep things simple a certain generalization has to be accepted.

Early warning systems are working with such generalizations and issue alerts with specific advises when reaching a certain danger levels is forecasted. In the FbF approach locally adjusted danger levels are used and they may differ from official danger levels. For practical reasons FbF works with only one danger level for a specific local area right now. The same applies to the FFWC for their water level stations.

Defining a danger level is in the first place a decision by communities. In a second step an assisting institution (e.g. the government or BDRCS/GRC) will need to find out who would when reach this danger level. For example a certain flood water height ("knee high") may only affect part of a community and it needs to be decided whether the danger level is reached when certain percentage of the community is affected by it. In view of limited resources of assisting organizations the statistical frequency of reaching the danger level needs to be considered as well.

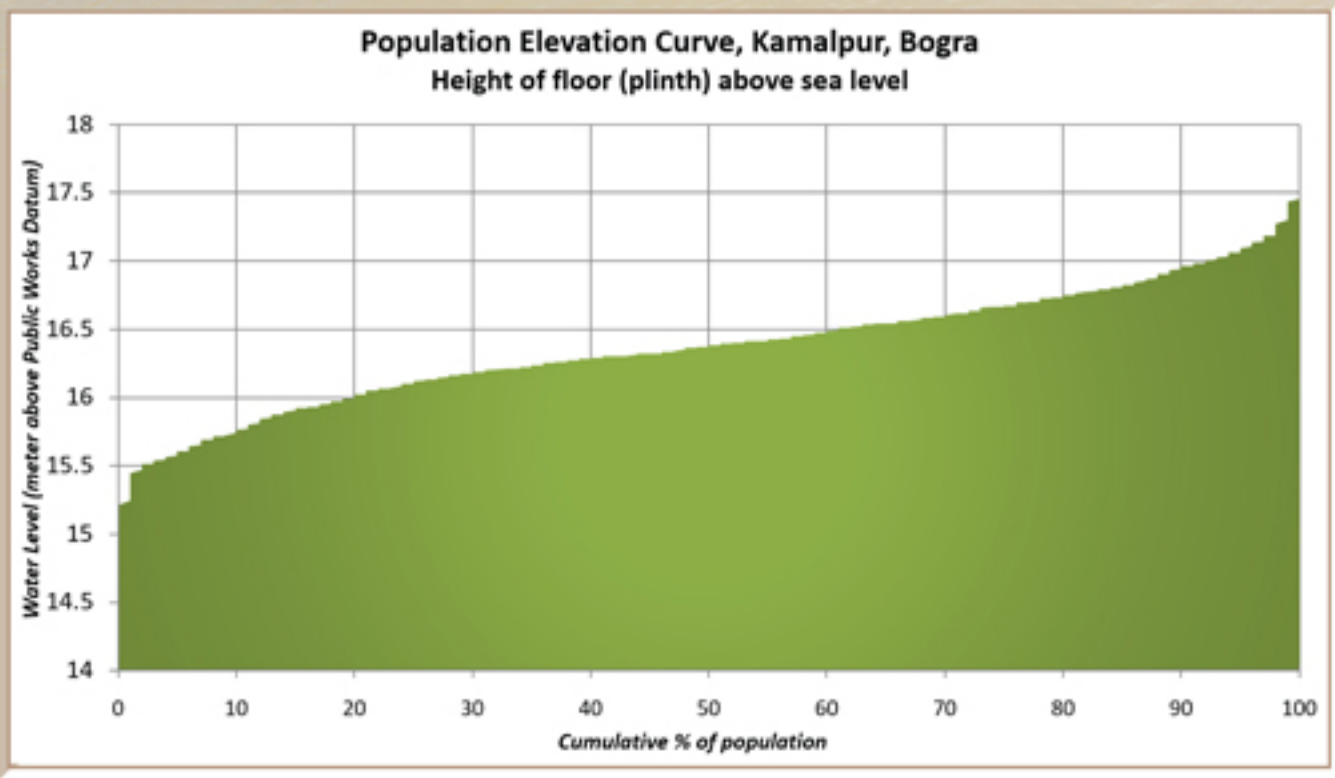
After the community members defined a danger level it is possible to determine with scientific methods how it will be applied locally.

Danger Level in Flood Prone Areas

BDRCS/GRC conducted semi-structured interviews and focus group discussions with community members and in their perception water entering their houses is a signal to take preparatory actions and therefore this is from their perspective an adequate danger level. Furthermore it was decided that the trigger for actions by BDRCS/GRC will only be reached when at least 20-30% of the houses have their floors flooded.

To determine the danger levels for all residential houses in a community as well as other assets BDRCS/GRC surveyed the villages using conventional leveling methods and GPS. Crop field spot heights with 10m x 10m spacing were collected using total stations. Different land uses (cropping patterns) were recorded too. In addition, the infrastructures (flood shelters, roads, embankments, education and health centers etc) were surveyed to find out at which water level the services and communications are disrupted due to flood.

During the elevation survey, basic data and socio economic information of each household was collected and used to generate a population-elevation curve. The percentage of people living at respective elevation has been calculated with respect to the plinth/floor level of the living room. For example about 20% of the population in the Kamalpur pilot site live at or below 16.2 m Public Works Datum (PWD) and this value is taken as the preliminary danger level for Kamalpur. There is a need to verify its accuracy and to make a final choice by selecting from the menu of triggers.


Population Elevation Curve, Kamalpur, Bogra
Height of floor (plinth) above sea level
Water Level (meter above Public Works Datum)
18
17.5
17
16.5
16
15.5
15
14.5
14
0
10
20
30
40
50
60
70
80
90
100
Cumulative % of population

Danger Level in Cyclone Affected Areas

Generally speaking the coastal population regards Signal No. 5 and higher (more than 87 km/h wind speed) as a dangerous development and sees the need to take preparatory actions. Though cyclones are categorized by maximum wind speeds they are often accompanied by excessive rain and storm surges. The latter one is the most dangerous feature of a tropical cyclone as most deaths related to such storms are actually victims of storm surges. As it is much more difficult to predict storm surges than the wind speed, meteorological offices often issue clear warnings based on air velocities but not based on expected water heights. This applies also to Bangladesh where the storm warning signals are not considering storm surges. However, expected coastal surge heights are also published for three ports and other key locations.

Storm surges are caused by high winds towards the coast and low air pressure sucking water towards the eye of a cyclone. Depending on the severity of the storm and local circumstances like bathymetry the water may rise several meters high. It is important to consider the lunar tide when forecasting the effective height of the water on land. The surge height adds to the lunar tide. This means storm surges are especially dangerous when they coincide with a high lunar tide.

Most inhabited coastal areas are protected from storm surges by dikes/embankments of 5-6m height. Only few people live outside the embankment. The condition of the dikes is in many areas questionable and it is not guaranteed that they will effectively hold the storm surge water off. It is highly recommended that the people retreat to cyclone shelters even if no serious storm surge is predicted.

BDRCS/GRC decided to take the expected wind speed of Signal 5 if a track forecast sees the track within 100 km of the target communities as a trigger. This applies also if the wind speed of a cyclone is lower than 88 km/h at the time of the forecast, but is expected to increase in wind speed until being at close range to Hatiya/Noakhali. Another condition which may trigger BDRCS/GRC actions is the forecasted storm surge height. If the BMD announced surge height plus the lunar tide height at the time of the expected arrival of the eye of the cyclone in Hatiya/Noakhali is higher than the embankment BDRCS/GRC use this as a trigger even if the wind speeds are not predicted to be 88+ km/h. The dikes in Hatiya are 5 m high and in mainland Noakhali 6 m (Companiganj).

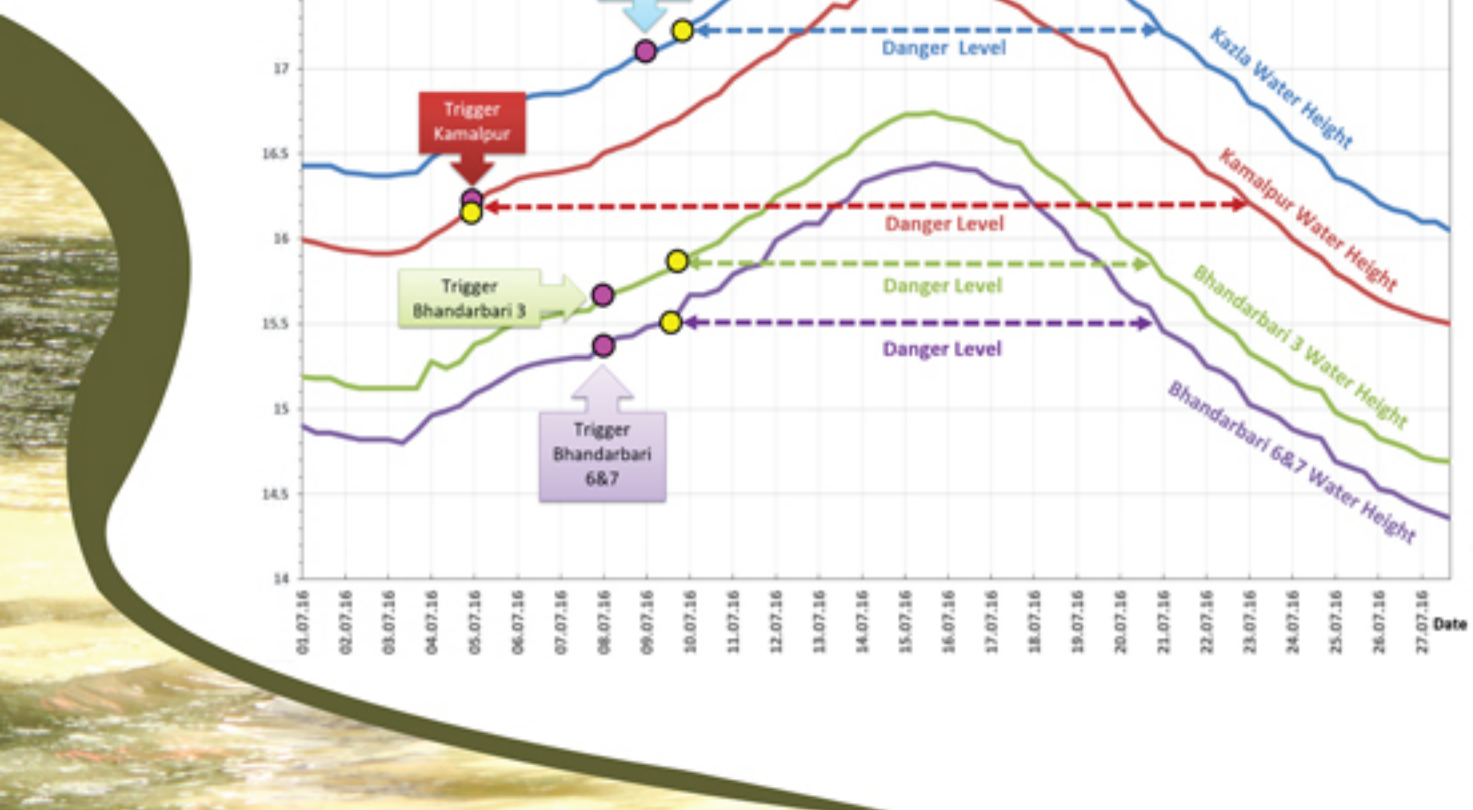
BDRCS/GRC monitored the tides at the target communities and related them to the nearest governmental tide stations. With this it is possible to make quite precise local, effective storm surge height predictions.

Step 3: Assess the Accuracy of Forecasts

In order to select and define the triggers, it is important to know the accuracy of crossing the danger level. In this step, the accuracy of the forecast for a specific hazard is assessed for each lead time by calculating the hit rate and false alarm ratios. More lead time means more time for forecast-based actions, but longer forecast times mean also less accuracy and higher chances to "act in vain". "Acting in vain" refers to actions taken based on forecasts overestimating the severity of an extreme event beyond the danger level/trigger. However, the impact on the community is still significant if the danger level is almost reached and the actions might still be helping communities to deal with the adverse effects of the hazard event.

Flood affected areas

The FFWC 48 hour deterministic forecast is highly reliable, which means over 90% certainty and the variation in water level is within 15 cm and also shows a high hit rate (HR) of 0.84 and the false alarm ratio (FAR) is 21%. The five days forecast has a mean absolute error (MAE) of about 0.6 meters, which means it is useful but it has a low reliability. FFWC also forecasts with 10 days lead time, which has mean error of over 1.2 meters. Before the floods in July 2016 GRC used the forecasts of FFWC. It appeared that FFWC underestimated the rapid increase in flood waters and the danger levels were reached within one or two days when this was predicted to take three or more days.



Cyclone affected areas

The records of BMD show that about 11% of Signal 4 storms did neither cross over the Bangladesh coast nor intensified to Signal 5 or higher.

Step 4: Preparation of the Menu of Triggers and Trigger Selection

In view of the evaluation of available information, the definition of triggers and the assessment of the accuracy of forecasts different trigger options may be compared using a set of criteria:

- Does the lead time provide enough time for practical actions before the onset of the extreme event?
- Is the accuracy of the forecast acceptable in view of "acting in vain"?
- Is the statistical frequency too high in view of limited resources for taking actions?

Trigger Options for Flood Affected Areas

The table below represents a sample menu of triggers for the BDRCS/GRC pilot sites in the Bogra district. Three options were developed based on the key criteria of lead time, accuracy and frequency. The lead times are 3, 5, and 7 days. The accuracy is calculated by using the hit rate and false alarm ratio which was found to be 0.84 and 0.21 respectively for 3 days. The frequency of an event crossing the danger level is calculated using historical data.

Menu of Triggers, Pilot Sites in Bogra District

Forecast	Trigger Options - Flood		
Option number	1	2	3
Lead Time (days)	3	5	7
Accuracy (hit rate)	0.84	0.533	0.20

The table represents a menu of triggers for the pilot sites in the Bogra district. Three options were developed with the variables like the lead time, accuracy and frequency of the forecast to exceed the danger level. This is a good basis for informed decision making and it should be made in consultation with the communities.

Trigger Options for Cyclone Affected Areas

The table represents the menu of triggers used for the pilot sites in the Noakhali district. Three options were developed with the variables like the warning signals, lead time, landfall time & storm surge height, accuracy and frequency of the forecast to exceed the danger level (winds or surges).

Menu of Triggers, Cyclone in Noakhali District

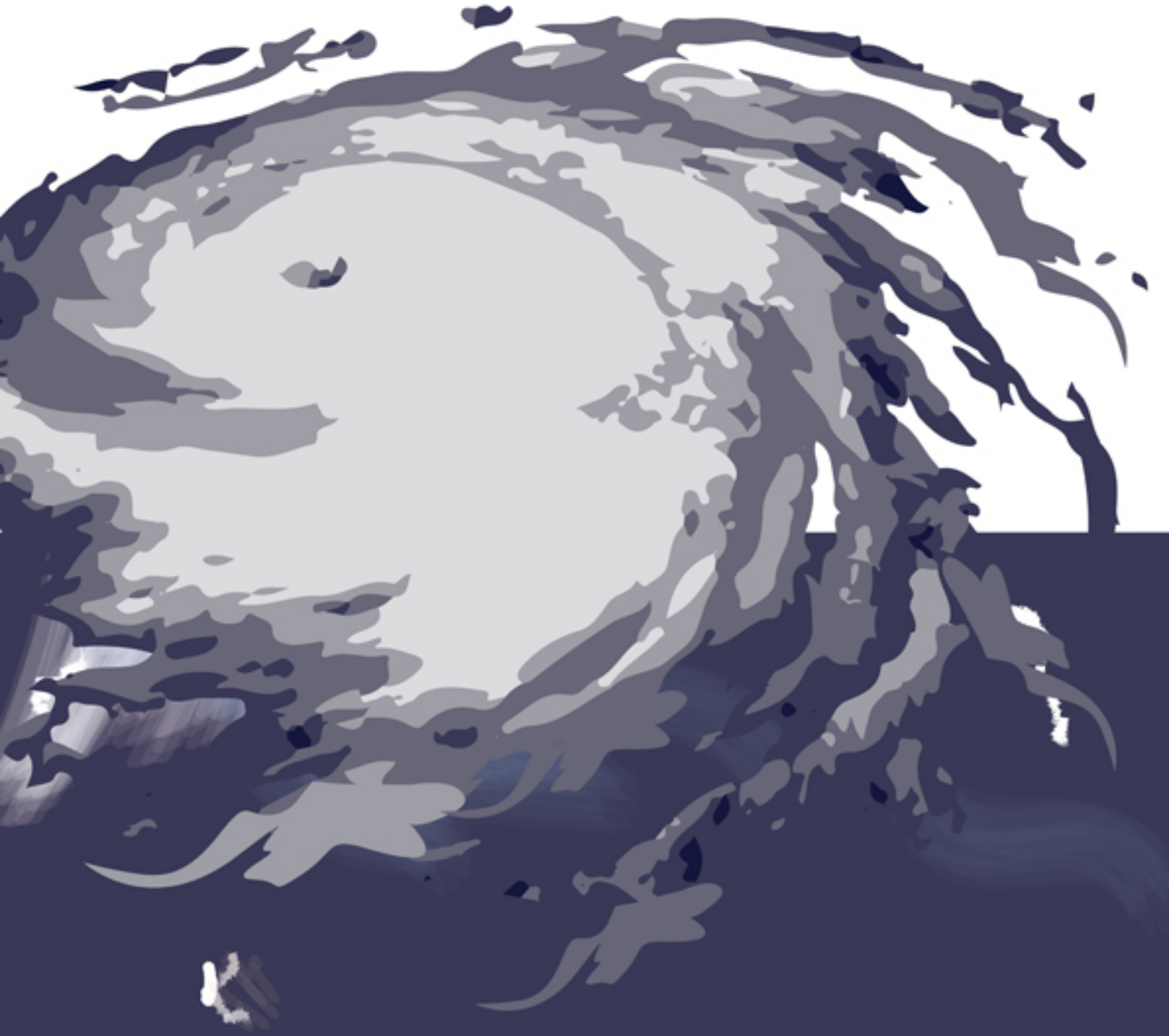
Forecast	Trigger Options		
Option number	1	2	3
Warning Signals, BMD	4 potential to increase to signal 5 or more	7 Cyclonic Storm	10 Severe Cyclonic Storm,Very Severe Cyclonic Storm
Maximum wind speed	62 km/h (potential to increase higher)	63 – 87 km/h	88 – 118 km/h
Landfall / Track	Hatiya Coast line: +/- 100 km	Hatiya Coast line: +/- 100 km	Hatiya Coast line: +/- 100 km
Storm surge	TL-lf + WH-lf > Embankment height	TL-lf + WH-lf > Embankment height	TL-lf + WH-lf > Embankment height
Lead Time (hours)	48-72	18-36	12-18
Frequency	7 in 10 years	1.2 in 10 years	1.2 in 10 years

The menu was discussed with experts from BMD and Ministry of Disaster Management and Relief. Finally BDRCS/GRC decided to use option 1as trigger for the SOP.

The SOP will be triggered 48 hours before the expected landfall of a cyclone in the BDRCS/GRC project area when one of the following conditions are met:

- The BMD forecast shows the track to cross over the Hatiya/Noakhali (center line +/-100 km), and the maximum forecasted wind speed is at least 62 km/h (Signal 5 or higher).
- The forecasted wave height is higher than the height of the embankment (storm surge height + tidal water height).

Note: The decision to trigger will happen only 48 hours before expected landfall. If forecast less than 48 hours see a storm approaching Hatiya/Noakhali with more than 61 km/h the SOP will not be activated anymore as there would not be enough time to prepare for the impact of the storm.



Bangladesh Red Crescent Society (BDRCS)

Consitutituted in 1971, the BDRCS is a reliable partner with a big and countrywide volunteer base (68 branches, approx.. 300,000 volunteers), excellent Disaster Preparedness (DP) and Disaster Response (DR) skills and a countrywide health network. The chairman has been constitutionally appointed by the president of Bangladesh, the ex-officio president of the society

International Federation of Red Cross and Red Crescent Societies (IFRC)

The IFRC delegation has been located in Dhaka since 1986. In August 2003 it signed a legal status agreement with the government of Bangladesh. I is providing organisational support to the BDRCS and has always been an effective partner in coordinating the various relief operations.

German Red Cross (GRC)

GRC works under the umbrella of the IFRC in Bangladesh. In addition GRC and BDRCS have outlined their working relationship in a Memorandum of Understanding and each project is arranged with a project agreement. GRC is mainly supporting emergency operations, primary health care, disaster preparedness, disaster risk reduction, climate change adaptation and organisational development.

Red Cross / Red Crescent Climate Centre (RCCC)

The RCCC is the reference centre of IFRC with the mission to help the Red Cross and Red Crescent movement and its partners reduce the impacts of climate change and extreme-weather events on vulnerable people. In FbF, the Climate Centre provides technical assistance with tools and techniques to set up triggers, danger levels and monitoring systems.

German Federal Foreign Office

Within the German Government, responsibility for humanitarian assistance lies with the Federal Foreign Office. The Federal Foreign Office cooperates with specialist partners to implement these projects. These include, alongside the Federal Agency for Technical Relief, numerous non governmental organisations such as the German Red Cross as well as the humanitarian agencies of the United Nations and others.

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