This document sets out the best sources of useful information to look at when considering anticipatory humanitarian action in advance of tropical cyclones in the Philippines. It has been produced by Dr Erica Thompson of LSE’s Centre for the Analysis of Time Series (funded by the Natural Environment Research Council) in partnership with the Start Network.

Executive Summary

- Very strong tropical storms are called typhoons, cyclones and hurricanes in different regions around the world but these refer to the same kind of weather event generically called a cyclone.

- Cyclones are divided into categories such as “tropical storm”, “typhoon” or “category 4 hurricane” by wind speed only. The category alone is therefore not enough to assess potential humanitarian impact.

- Official warnings and advisories are issued by national weather services, usually in a set format. Most will not offer public warnings early enough to inform anticipation alerts.

- Public alerts are based on forecasts by the relevant one of six *Regional Specialised Weather Centres*. Forecasts will also be available from the Joint Typhoon Warning Centre and raw model data from ECMWF. Cyclone forecasts also indicate levels of confidence.

- There are three main causes of humanitarian impacts from tropical cyclones: strong winds, high rainfall, and storm surge, which should be considered separately and together when assessing the risk.
  - **Strong winds** cause physical damage to buildings and infrastructure. Damage is dependent on the wind speed and on the quality of the buildings. Locations close to the centre (“eye”) of the cyclone will experience extremely strong winds. The impact of the strongest winds is generally localized, extending a few tens of kilometres from the point of landfall.
  - **High rainfall**, may cause flash flooding, landslides or lahar. When a cyclone makes landfall near a hilly or mountainous area, larger amounts of rain can be expected over the hills. High rainfall can be experienced over an area many hundreds of kilometres across and subsequent river flooding may last for several days.
  - **Storm surge**, a temporary increase in sea level, causes coastal flooding. This may be particularly severe where the coastline “funnels” surge water into a bay or estuary, and where the time of the surge corresponds with a high tide. The peak of the danger only lasts for a few hours.

- Typhoons may be identified as a potential risk 4-8 days before making landfall. At this point, the confidence may not be high enough to activate an alert. Consider submitting an alert with identified checkpoints for activation or withdrawal of the alert in a further 48 hours.

- Seasonal or “long-range” storm risk predictions are low skill, refer to seasonal totals and large areas, and are not worth taking into account when preparing an alert. Similarly, climatic averages and climate change trends are not relevant to operational decisions.
What are tropical cyclones and what are the associated hazards?

A tropical cyclone is a well-defined weather feature which consists of high winds and bands of cloud/rain rotating around a central point of low pressure. Tropical cyclones (also called hurricanes or typhoons) form and strengthen while over warm tropical oceans. Typically, they weaken and dissipate over land, over areas of cooler water, or when they pass out of the tropical regions. In the Northern Hemisphere, the strongest winds are in the front right quadrant as shown. In the Southern Hemisphere, the strongest winds are in the front left.

The worst storm surge and rainfall impacts can occur with lower category tropical cyclones

Storm strength is historically classified by wind speed. This can be misleading in terms of impact: extreme rainfall can occur even for cyclones with lower wind speeds. Tropical Depression Usman in December 2018, for example, never reached “typhoon” status at all, but heavy rainfall triggered landslides with the loss of over 150 lives. The impact of storm surge is very dependent on the geography of the coastline and the timing of landfall: again, the highest wind speeds do not always correspond to the greatest storm surge.

The category of storm alone is not enough to assess potential humanitarian impact
Damage due to strong winds is dependent on the wind speed and direction, and on the quality of the buildings themselves. Locations close to the centre (“eye”) of the cyclone will experience extremely strong winds from one direction, followed shortly by extremely strong winds from the opposite direction. The strongest winds and gusts occur at the “eye wall” of the cyclone and they get weaker further out. Winds are stronger over the ocean where there is nothing in the way; when the cyclone makes landfall, the winds are slowed down by hills, trees and buildings. The storm itself also weakens rapidly when it moves over land, since its energy source is warm ocean water.

**Therefore, the greatest impact of strong winds is highly localized around the point of landfall, but this is often difficult to predict until very close to the time of landfall itself.**

Wind speeds close to the eye are indicated by the category of storm. The highest category of wind speeds will cause catastrophic damage to almost all buildings but wind speeds further out may also be damaging. JTWC advisories will show the position of strong winds and the radius (distance from eye) of wind thresholds. For example, if the 50kt radius is 45nm in the SE quadrant, this means that wind speeds of 50kt (92kph) are found up to a distance of 45nm (83km) to the south-east of the cyclone centre. Over land, measured wind speeds will be significantly lower. In the Northern Hemisphere, the strongest winds are in the “front right” quadrant of the storm, with respect to the direction of travel (see Fig 1). In the Southern Hemisphere, the strongest winds are in the front left.

**Across different regions, the terminology used to refer to cyclones is different. In addition to the change in generic terminology (hurricane/cyclone/typhoon), the thresholds used to define different categories of storm are different. This table compares the words used in different regions. Categories are defined only by maximum wind speed, although even this can be inconsistent as some refer to the maximum wind sustained for one minute and others for ten minutes. A key point is not to attach too much importance to exact wind speeds or crossing of arbitrary thresholds.**

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**FIGURE 2**

There are three main causes of humanitarian impacts from tropical cyclones: strong winds, high rainfall, and storm surge, which should be considered separately and together when assessing the forecast risk.
2. HIGH RAINFALL

The consequences of extreme rainfall often cause the primary humanitarian impacts.

High rainfall can be experienced over an area many hundreds of kilometres across. Flash flooding may occur immediately and subsequent river flooding may last for several days as the water works its way down through river basins. When a cyclone makes landfall near a hilly or mountainous area, larger amounts of rain are expected on the seaward side of hills. After the storm has weakened in (wind-speed) intensity, extreme rainfall may continue.

It is often very difficult to make accurate rainfall predictions for a tropical cyclone, because the amounts are so large and because the storm picks up moisture all the time it is over warm water. The best available rainfall forecasts are usually provided by the national weather service. If a flood risk assessment has been carried out for the region, it may be possible to identify areas at risk. GloFAS provides physical hazard maps combining weather modelling and river flow modelling to map where particularly high river levels are expected.

3. STORM SURGE

This may be particularly severe where the geography of the coastline “funnels” surge water into a bay or estuary, and where the time of the surge corresponds with a high tide. The peak of the danger due to incoming storm surge, accompanied by powerful breaking waves which may damage coastal infrastructure, only lasts for a few hours.

In addition, high waves or ocean swell will precede the storm and may be a danger to shipping and small fishing boats, or to coastal infrastructure when they coincide with high tide.

Landslide of volcanic debris due to heavy rainfall is termed lahar, and should be considered when a cyclone passes close to an area where volcanic activity has deposited a lot of volcanic material.

National weather forecasts will include best information about cyclone rainfall.
How reliable are the forecasts at different lead times?

Some storm tracks are easier to forecast with more confidence than others. On the public web pages of the European Centre for Medium-range Weather Forecasting (ECMWF) we can view forecasts of the track and intensity of all cyclones, typhoons and hurricanes identified. They run lots of slightly different forecasts (called an "ensemble") to get an idea of the level of confidence in the forecast track.

**FIGURE 5**

ECMWF forecast intensity and track for Cyclone Mangkhut on (left) 7th September 2018 and (right) five days later on 12th September 2018. From ECMWF here.

**LEFT:** Note that the storm continues to intensify for the next eight days while the cyclone is over warm water. 100 knots is 185 km/h or 115mph. Note that there is good agreement (high confidence) until Day 5 when the storm changes direction. While continuously monitoring the progress of this storm, a reassessment at around Day 5 (12 Sept) would be appropriate.

**RIGHT:** On 12th September the wind speed has intensified considerably more than originally forecast, and is projected to stay strong for another five days until Mangkhut makes landfall in China. The track projections are in agreement that the storm will pass over or close to the northern end of Luzon after another 3 days (15th September).

For the forecast shown in Figure 5, on the 7th of September a strong cyclone was developing but it was not clear whether it would even hit the Philippines. By the 12th, there was high confidence that a strong cyclone would hit the north of the country on the 15th. With monitoring, the alert could have been written at some point between the 7th and 12th and activated on the 12th with three days of lead time for projects. The government response was already under way on September 13th with evacuations and mobilization.
The key question is: **what level of confidence is required before an alert is issued?** If a large cyclone is approaching a uniformly populated coastline then we could issue an alert knowing that there will be a high level of impact regardless of where it hits. But if it is approaching a sparsely-populated coastline with a single big city which may or may not be hit, or if there is still a high likelihood of no landfall at all, then it might make more sense to wait until there is greater confidence in the forecast.

As noted above, the reliability of the forecast varies from one event to the next and it is often possible to identify when the forecast is likely to be more or less confident. There is often more confidence in the progress of larger storms, since they form in more ideal conditions.

**FIGURE 6**

*Average track error for three cyclone forecasts (km), and a table to aid quick interpretation. Picture from Yamaguchi et al, BAMS, 2017.*

Tropical cyclone advisories give the expected time and position of any landfall. These advisories usually also indicate the level of confidence. An example from JTWC:

**NUMERICAL MODEL GUIDANCE IS IN EXCELLENT AGREEMENT IN THE NEAR TERM, LENDING HIGH CONFIDENCE TO THE JTWC FORECAST TRACK. GUIDANCE AFTER THE FORECAST PERIOD DIVERGES SIGNIFICANTLY,**

Because different sources generally rely on the same tracked and forecast data, it is not necessary to consult all of the different sites making this data available. Agreement would not indicate greater confidence.

In general, the best information will come from the local Regional Specialized Meteorological Center: [http://severeweather.wmo.int/v2/rsmcs.html](http://severeweather.wmo.int/v2/rsmcs.html)

In addition, the information available via ECMWF may help when considering an alert timeline, but this information is already taken into account by the RSMC forecast.
Making the alert timeline work

Up to now, it has been very challenging to make alerts for tropical cyclones due to the short window for anticipatory action. Feedback from in-country representatives has raised the following possibilities for streamlining the alert process:

- **Draft an alert template in advance.**
  What actions can be taken 1, 2, 3 days before the storm hits, if there is sufficient confidence? This template can be discussed and help to produce the alert note quickly.

- **Monitor the situation regularly to spot developing risks early.**

- **Keep in touch with updates on all developing risks.**

- **Submit alert note with a condition for activation.**
  For example, reassessing the storm in say 24 or 48 hours and activating or withdrawing the alert based on latest forecast.

- **Request a 12 hour turnaround.**
  This may be possible, if a cyclone has unexpectedly appeared, strengthened, or changed track and it is critical to act immediately.
USING FORECASTS TO SUPPORT ANTICIPATORY ACTION

It’s important to have a contingency plan with identified actions at certain lead-times developed and agreed with partners in advance.

O1 Use the JTWC map to monitor the emergence of potential cyclones in vulnerable land areas.

Areas of tropical cyclone development will be circled. Use NHC for Atlantic hurricanes.

O2 If a cyclone is developing, look at JTWC warning graphic to see whether it is forecast to move towards vulnerable land areas.

If so, consult ECMWF web page for timescale and confidence in the forecast. There is likely to be 4-8 days warning at this stage.

O3 Consider appropriate timescale for alert.

- Is there an indication in the TC advisory from JTWC about when the track may have greater confidence?
- Is there a point at which the ECMWF forecast tracks diverge or change direction?
- Would an alert issued at that point give enough time for suitable anticipatory action?
- What changes to the alert cycle would you recommend? (eg. 12 hours for the allocation decision? Would you want to include a ‘check-point’ that decision-makers can evaluate during the allocation meeting—such as if a cyclone path continues as was expected etc).

O4 Gather related data:

- A Where is the cyclone likely to hit? (ECMWF)
- B What category storm could it be at that point? (ECMWF)
- C Is the storm moving fast (lower risk of extreme rainfall) or slowly (higher risk of extreme rainfall) when/after it makes landfall? (ECMWF)
- D How confident is the cyclone track forecast? (ECMWF/JTWC)
- E What communities may be affected?
- F What is the existing context for humanitarian need in those communities?
- G Are any parts of the area vulnerable to storm surge hazard?
- H Are any parts of the area vulnerable to landslide hazard?
- I If extreme rainfall were to occur, which parts of the area would experience river flooding?

O5 Raise anticipatory alert based on your understanding of the humanitarian situation and on weather forecast information as above.

Before raising an anticipation alert, please take a look at the critical questions that decision-makers consider before activating an anticipation alert.

Consider including a “checkpoint” to reassess the forecast in 24 or 48h and retract or confirm the alert.

FURTHER READING


IF YOU HAVE ADDITIONAL QUESTIONS OR IF YOU WOULD LIKE TECHNICAL SUPPORT USING AND INTERPRETING CYCLONE FORECASTS, PLEASE CONTACT THE START FUND TEAM: startfund@startprogrammes.org