*Trans. Nat. Acad. Sci. Technol. 14:15-23.1992*

# WARNING SYSTEM FOR WEATHER-RELATED HAZARDS

Dr. Leoncio A. Amadore
Deputy Director
Research and Development
Philippine Atmospheric, Geophysical and
Astronomical Services Administration (PAGASA)
Department of Science and Technology (DOST)
ASIATRUST Bank Bldg., 1424
Quezon Ave., Quezon City

## ABSTRACT

The weather-related hazards affecting the Philippines are typhoons, with the accompanying high winds, storm surges, and heavy rains; floods and landslides caused by prolonged and intense rainfall due to the southwest and northeast monsoons; thunderstorms, tornadoes/waterspouts, etc. Casualty and damage to property due to these fastonset but predictable disaster-agents are increasing with the years. An effective early warning system can possibly reduce the loss of life and mitigate the adverse effects of such disasters.

The components of the warning system for typhoons and floods are discussed and analyzed. The detection and monitoring component has been strenghtened with the installation of remote sensing and telemetering facilities. However, the forecasting aspect of the system needs further improvement through the research and development. The component on warning formulation and dissemination can be enhanced by appropriate innovations in the warning message and through the dynamic participation of the mass media. Community preparedness and users' response to the warning is admittedly the most challenging component of the system since it involves the participation of disaster-oriented organizations and the general public.

The warning system can be more effective if the warning message reaches the end-users on time and is fully understood by them, the level of disaster awareness of the general public increased, the accuracy of the forecast improved, the active participation of local disaster organizations enhanced, and the disaster culture of the community rationalized.

## Introduction

A hazard is, generally, defined as a potentially harmful condition. Hence, typhoons, floods, volcanic eruptions, or earthquakes are simply considered as natural hazards and not disasters themselves unless they occur in developed and inhabited areas where they cause damage to property and loss of life.

Natural disasters are usually preceded by changes in the normal state of the environment. For instance, prolonged heavy rainfall is nature's way of warning people of an impending flood or landslide. Dark red coloration of clouds at sunrise and sunset, persistent sea swells at coastal areas, etc., are some of the precursory signs of a coming typhoon. Moreover, long-time residents of a community are aware of the time of year typhoons usually occur, the period of rainy or dry seasons and ensuing floods and drought or near drought situations.

Storm surge usually occurs at surge-prone areas during the height of a strong, intense typhoon. Gradually increasing wind speed and deteriorating weather conditions during a typhoon's passage are a warning of possible storm surge occurrence.

For some non-predictable geological hazards such as earthquakes, natural warnings are admittedly not so well understood and defined, although their occurrences are reportedly indicated by unusual animal behavior and other precursory signs. However, major volcanic eruptions, such as that of Mt. Pinatubo are usually preceded by minor earthquakes, rumblings, smoke emission, etc. Subsequent lahar flows which often cause more casualties and devastation than the eruption itself, could be anticipated with the occurrence of heavy, continuous rains over the area.

For slow-onset, large scale events, such as drought and the impending global climate change, the various natural processes or changes leading to such events may not be readily perceptible to the layman, but nature has its own way of warning man of their occurrences. In the case of climate change, the warning is already ON!

## 2. Weather-related Hazards Affecting the Philippines

Typhoons, with the accompanying storm surges, high winds, heavy rains and the resulting floods are the most common causes of natural disasters in the country. Other weather-related hazards include the monsoons which usually cause floods, tornado/waterspout, and severe thunderstorms.

A tropical cyclone, whatever its strength, is known all over the country as "bagyo". The typhoon is the strongest (with maximum winds of 180 KPH or more) and oftentimes the most destructive of all types of tropical cyclones, in particular, and of all weather-related disasters affecting the country, in general. The other types of tropical cyclones, such as the tropical strom (63 to 117 KPH) and the tropical depression (maximum winds of up to 63 KPH) do not have as strong winds as typhoons, but are usually associated with heavy rains which cause extensive flooding. An annual average of 9 tropical cyclones, consisting of 4 typhoons, 2 tropical storms and 3 tropical depressions cross the country. In addition, about 2 tropical cyclones, which do not make their landfall, may intensify the monsoon rains and cause flooding. A tropical cyclone may occur any month of the year but has its peak during July and August. The period from June to December is generally considered as the tropical cyclone season.

Likewise, the country is adversely affected by both the northeast (NE) and southwest (SW) monsoons. Generally, during the months of December, January, February and early March, the prevailing wind flow is from the northeast. This relatively cold, gentle wind from the Asiatic continent is popularly called the "amihan". The southwest monsoon is usually from late May to September when the predominant wind direction is from the southwest, and locally known as the "habagat". A tropical cyclone or low-pressure area could intensify the northeast or southwest monsoon, giving heavy and sometimes prolonged rainfall and consequently, extensive flooding over low-lying areas.

A tropical cyclone or a low-pressure area located northeast of the Philippines or in the south China sea could intensify this moist-laden southwest wind flow bringing in heavy and sometimes prolonged rainfall over the western part of the country. The episodic floods of 1972, 1974, 1976 and the current intensified lahar flow in Mt. Pinatubo area in Central Luzon were caused principally by the southwest monsoon.

Another hazard associated with intense typhoon is the storm surge. It is characterized by a sudden rise of water (sea) level along the coast at or near the place of landfall of a typhoon, usually up to a hundred kilometers or so north of it. The rise in water level could be as high as five meters or more. The strong winds, the swift current, together with the wave action due to big swells, could sweep away rows and rows of houses along the shore. Deaths and injuries are usually high when a storm surge is generated by a typhoon.

Statistics show that casualty and damage to property due to typhoons in the Philippines generally increase with the years (Figure 1), whereas in more developed countries, casualty is on the downtrend. For such predictable natural hazards as typhoons and floods, deaths and injuries may be avoided and damage to property minimized, if the proper measures are implemented by the individual and community immediately before and during the occurrence of the disaster. This, in turn, depends to a great extent on the effectiveness of the early warning system.

### 3. The Typhoon and Flood Warning System

It was pointed out in the previous discussions that nature has various ways of warning man of an impending disaster. Out of these ways evolved a systematic method of warning the populace, based on experience of past disasters and on recent advances in science and technology - the early warning system (Figure 2). For predictable, sudden-onset natural hazards, such as typhoons and floods, a longer lead time is made available to disaster mitigation organizations and the general public to set into motion disaster preparedness measures designed to mitigate the adverse effects of an impending disaster.

The warning system has generally four components, namely: a) detection and monitoring of the hazard, b) forecasting the hazard, c) formulation and dissemination of the warning, and d) preparedness and users' response to the warning. The ensuing discussions will focus mainly on the warning system for typhoons and floods.

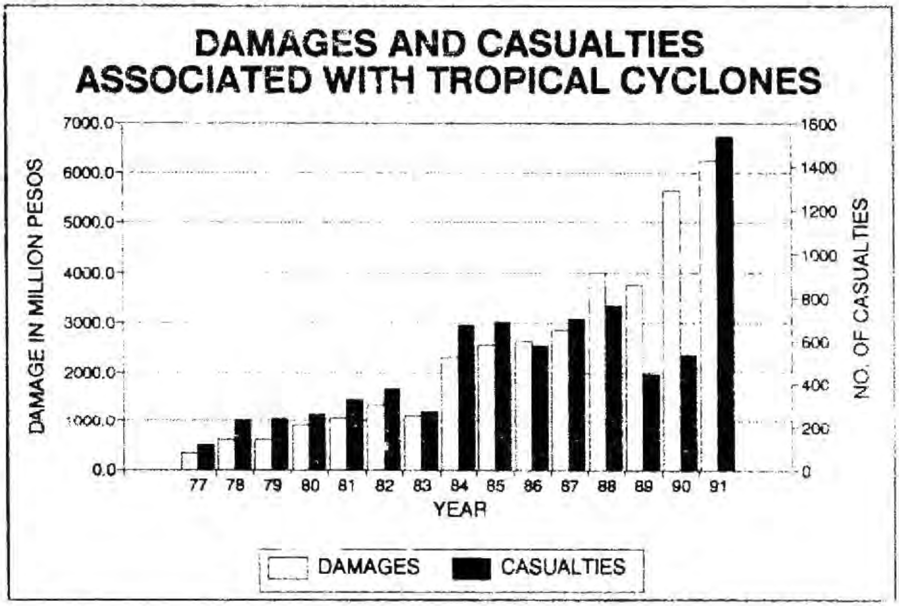


**Figure 1. 5-Year Running Mean of Damage and Casualties**

### Detection and Monitoring of Typhoons and Floods

The detection and monitoring of typhoons and floods has been greatly enhanced by recent advances in science and technology. A typhoon, from its incipience in the vast Pacific ocean or in the south China sea, up to its dissipation can be detected and its movement, changes in intensity and structure can be monitored through remote sensing techniques, such as weather radars and satellites. The NOAA Satellite Receiving and Processing Facility has been recently established in PAGASA to supplement the GMS satellite receiver that has been giving quality satellite pictures of typhoons and other weather disturbances for the past several years.

Likewise, through telemetry, real time rainfall and river stage information at various observation points of a river basin can be made available for the purpose of detecting and monitoring floods. In the Philippines, a telemetered flood forecasting and warning system has been installed at the Pampanga, Agno, Bicol and Cagayan river basins and most recently at the Marikina river basin, including Laguna Lake and Metro Manila.

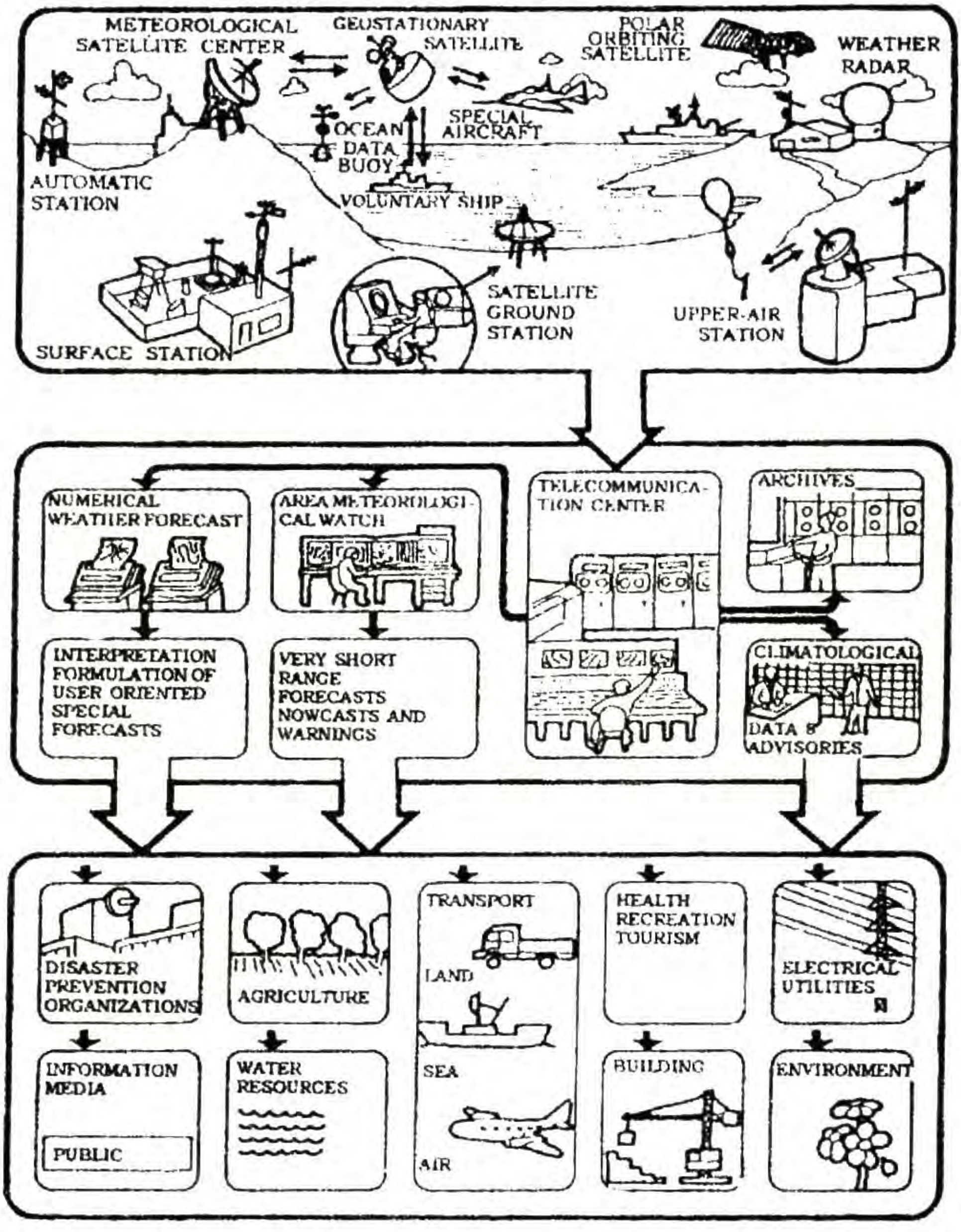


**Figure 2. The operation of a national Meteorological Service: observations, data collection and dissemination: data processing and preparation of forecasts, warnings and climatological advisories; dissemination of forecasts and other specialized information to users. (WMO)**

## Forecasting Typhoons and Floods

The present state of forecasting typhoons and floods is much more difficult than their detection and monitoring. Tropical weather systems, such as typhoons and the flood-causing monsoons, are generally less understood than their counterparts in temperate regions. Hence, the results of even the most sophisticated numerical models for the tropics are relatively less accurate than elsewhere.

Presently, the official typhoon forecast of PAGASA is a blend of both subjective and objective forecast methods. The subjective forecast method is based mainly on the forecaster's interpretation of weather systems and other factors affecting typhoon movement and development. There are about a dozen or so computerized objective techniques of forecasting movement, which are currently used by PAGASA, many of them developed by Filipino meteorologists.

Similarly, the flood forecasts of PAGASA are based on the results of computer models and the forecaster's assessment of the affected river basin's conditions.

Needless to say, the reliability of a forecast as gauged by its accuracy is a necessary factor to ensure appropriate and adequate user's response to the warning.

## Formulation and Dissemination of the Warning

Warning formulation, dissemination and eliciting prompt and proper users' response to the warning are basically multi-disciplinary activities. The warning may be viewed as an important link between the scientific community and the layman. Warnings are widely criticized for containing many technical terms not fully understood by the general public. To the forecasters who usually formulate the warnings, such technical terms are understandably clear. In order to effectively bridge this gap between the technical people and the general public, the social scientists and other disaster-oriented personnel should be consulted in setting up the general guidelines for warning formulation. Furthermore, it is likewise important that the needs and preferences of users of the warning be pre-determined through surveys or other feed-back mechanisms.

The most recent innovation adopted by PAGASA in its warning formulation is the increase in the number of Public Storm Signals (PSS) from PSS # 3 to PSS # 4 and the inclusion of the potential damage to structures and vegetation relative to each public storm signal (Table 1). The purpose of adding PSS # 4 to the previous signal system is to enhance the people's awareness of a very powerful typhoon threatening their community and for them to adopt the appropriate preparedness and mitigation measures against the impending disaster.

Experiences and realities have shown that warning dissemination cannot be done by the forecasting/warning agency alone, but needs to be a multi-agency activity in order to reach the greatest number of people. In the design of the warning dissemination scheme, several factors have to be taken into serious consideration. Proper cooperation and most important, commitments by various disaster-related organizations with communication linkages from the national down to the grassroots levels to cooperate in the widest possible dissemination of the warning should be observed. In this regard the tri-media, especially the television and radio broadcast media, are indispensable partners in real-time warning dissemination. Government organizations with communication facilities and NGO's with disaster-related functions should likewise be tapped for this purpose.

Table 1. Modified Storm Warning Signals

SIGNAL NUMBER 1:

MEANING: A TROPICAL CYCLONE IS THREATENING THE AREAS WHERE THIS SIGNAL IS IN EFFECT. WIND SPEED FROM 30 TO 60 KILOMETERS PER HOUR (KPH) IS EXPECTED WITHIN 36 HOURS.

SIGNAL NUMBER 2:
MEANING: THE STORM OR TYPHOON IS APPROACHING OR PASSING CLOSE TO THE AREAS WHERE THIS SIGNAL IS IN EFFECT. WIND SPEED OF OVER 60 TO 100 KPH IS EXPECTED WITHIN 24 HOURS.

SIGNAL NUMBER 3:
MEANING: THE CENTER OF A SEVERE STORM OR TYPHOON IS PASSING OVER OR EXPECTED TO PASS CLOSE TO THE AREAS WHERE THIS SIGNAL IS IN EFFECT. WIND SPEED OF OVER 100 TO 185 KPH IS EXPECTED WITHIN 18 HOURS.

SIGNAL NUMBER 4:
MEANING: THE CENTER OR EYE OF A VERY INTENSE TYPHOON IS PASSING OVER OR EXPECTED TO PASS VERY CLOSE TO THE AREAS WHERE THIS SIGNAL IS IN EFFECT WIND SPEED OF OVER 185 KPH IS EXPECTED WITHIN 12 HOURS.

## Community Preparedness and Users' Response

This is a multi-agency activity undertaken by the respective disaster-coordinating councils (DCC) of each locality, such as the PDCC (provincial), CDCC (city), MDCC (municipal) and BDCC (barangay).

Perhaps, the most important and, indeed very difficult, if not the most challenging component of the warning system is the users' response to the warning. Come to think of it – the whole warning system is designed for them, i.e., for their personal safety and minimization of loss or damage to their properties, yet some people simply ignore the warning message. There is, therefore, an urgent need to strengthen this component of the warning system, because no matter how accurate and timely the typhoon or flood warnings are, if the people concerned do not respond accordingly, the loss of lives and damage to properties will hardly be reduced!

## 4. Some Factors Affecting Human Response to the Warnings

Foremost, the warning must reach the intended users with sufficient lead time for them to make the necessary preparations. Here, the problems of communications and linkages are the key factors to be considered. This seems to be a common concern of developing countries, especially those composed of hundreds or thousands of small island communities, like the Philippines. However, much hope in overcoming this problem is pinned on recent advances in telecommunications technology, such as the satellite broadcasts of warnings to remote areas.

As mentioned earlier, it is also necessary that the warnings be fully understood by the general public in order that they may properly respond to the impending threat. With the continuing efforts of the warning agencies, in cooperation with other sectors of society, to improve the mechanism of conveying the warning message and its implications to the public, this problem seems to be tractable. Innovative approaches in public information and education through the tri-media and the educational system, respectively, could undoubtedly contribute to the better understanding of the warning.

The public confidence and the accuracy of the forecast portion of the warning are another very important factor with a considerable influence on the users' response to the warning. The tendency to remember only the "missed" or "near-missed" forecasts is probably a universal trait, so that the one or two occasions when the warning agency made inaccurate forecasts is used as an excuse for not heeding the warning. More so, due to the increasing sophistication in technological advances, it seems only natural for the public to expect better accuracy of the forecast. Technical problems related to the accuracy of the forecast are better addressed to the scientific community. A concerted effort by the national, regional and international research institutions should be exerted towards the improvement of the forecast accuracy of less-understood natural hazards, such as the weather systems of tropical origin. The perception that the warning message is a means of conveying to the public the inherent uncertainties in the forecast should further be promoted.

Another factor which may influence the peoples' response to the warning is the disaster culture of the community and their peculiar idiosyncrasies. In some areas which often experience disasters, a number of residents would understandably feel quite confident that if they survived past disasters, then they are likely to survive another one. Fatalism or the belief in putting their fate entirely in God's hands during the period of disasters, is another reason for ignoring the warning.

In some instances, residents of threatened areas would prefer to wait for the occurrence of precursory signs which they have experienced in past events before responding to the warning. Sometimes, such indicators do not occur at all, making residents ill-prepared for the ensuing emergency situations.

Local disaster organizations play a major role in eliciting the appropriate response to the warning by the people under their jurisdiction. It is widely recognized that the residents would respond more readily if persons of authority would personally advise them of the necessary preparedness measures to be taken when there is an impending or imminent threat of disasters. Many organizational structures on disaster mitigation appear to be impressive on paper, but there is a real need for such organizations to be at least functional during the entire disaster cycle, especially immediately before the onset of the disaster and during the emergency period.

## 5. Further Enhancement of the Warning System

The warning system plays a vital role in disaster mitigation, especially in the protection of life and property. Our experiences with typhoon-caused disasters and the more recent Mt. Pinatubo volcanic eruption attest to the usefulness of the early warning system and the necessity for its continuous review and improvement to further enhance the preparedness aspect of disaster management.

The emerging concept and practice of newscasting may find wide applications in typhoon and flood forecasting. Understandably, the clamor of the general public is for updated information about the hazard. This information will enhance better warning response since (as experienced forecasters may know) the shorter the forecast period and the closer the hazard draws to the threatened area, the more confidence there is in the accuracy of the forecast. On the other hand, the desirability of issuing extended forecasts of up to 48 or 72 hours should be seriously considered. This will give disaster-related agencies enough lead time to activate their organizations and prepare for the impending threat. Of course, these moves require inputs from research and related studies from the scientific community in terms of hard and soft technology.

For weather-related disasters, the integrity of the warning can be greatly enhanced by improving the accuracy of the forecast. In this regard, much hope is expected from numerical weather prediction models. As of now, there is plenty of room for improvement in the prediction of tropical weather systems, as well as in quantitative precipitation forecasting (QPF).