2. The Early Warning System

2.1 Components of the Early Warning System

Early warning provides communities with timely information, enabling them to prepare for an anticipated hazardous event such that the impacts of the event on lives, livelihood and property are minimized. The early warning process is dependent on the interplay of science, technology and socio-economic factors that dictate the manner in which people understand and react to disasters.

Five general components to effective early warning systems may be distinguished conceptually, though in practice these elements are closely inter-related. Nevertheless, these components provide a useful logical framework against which to assess early warning capacities.

- Risk Assessment, including hazard assessment and vulnerability analysis
- Hazard detection and prediction
- Formulation of warning messages
- Dissemination of warning messages
- Community response

The interaction of these elements is illustrated in the diagram of WMO's meteorological early warning system depicted in Figure 2.1.

2.1.1 Risk Assessment, Hazard Assessment and Vulnerability Analysis

Hazard assessment involves determining the probability of occurrence of such phenomenon based on data from observational records and assessing their areal extent and duration. Vulnerability analyses include mapping areas likely to be affected by the hazards, like inundation from floods or windstorms and determining the potential for loss of life and damage to life and property. Risk assessment applies estimates of hazard and vulnerability to determine the likely impact. According to the IDNDR, risk assessment is essential for policy decisions that translate warning information into effective preventive action.

Vulnerability to cyclones and floods is increasing with economic growth, high levels of investment and the establishment of infrastructure within the flood plains and coastal areas of the countries in South East Asia. Risk assessment is fundamental to disaster reduction and an essential component of a well-designed early warning, as it facilitates the targeting of early warning systems for optimum benefits in terms of communities at risk, both directly and indirectly. For instance, significant advances are being made in bringing the users and producers of climate information together in an effort to develop seasonal forecasts that are targeted to specific community and sectoral decision cycles.

2.1.2 Hazard Detection and Prediction

Loss of life and damage to property can be reduced significantly through accurate forecasts and timely warnings for disasters such as tropical cyclones and floods. Given the current state of forecasting skill and technologies, the lead-time for early warning ranges widely – from one hour for tornadoes and flash floods to seasonal and inter-annual forecasts of El Niño.

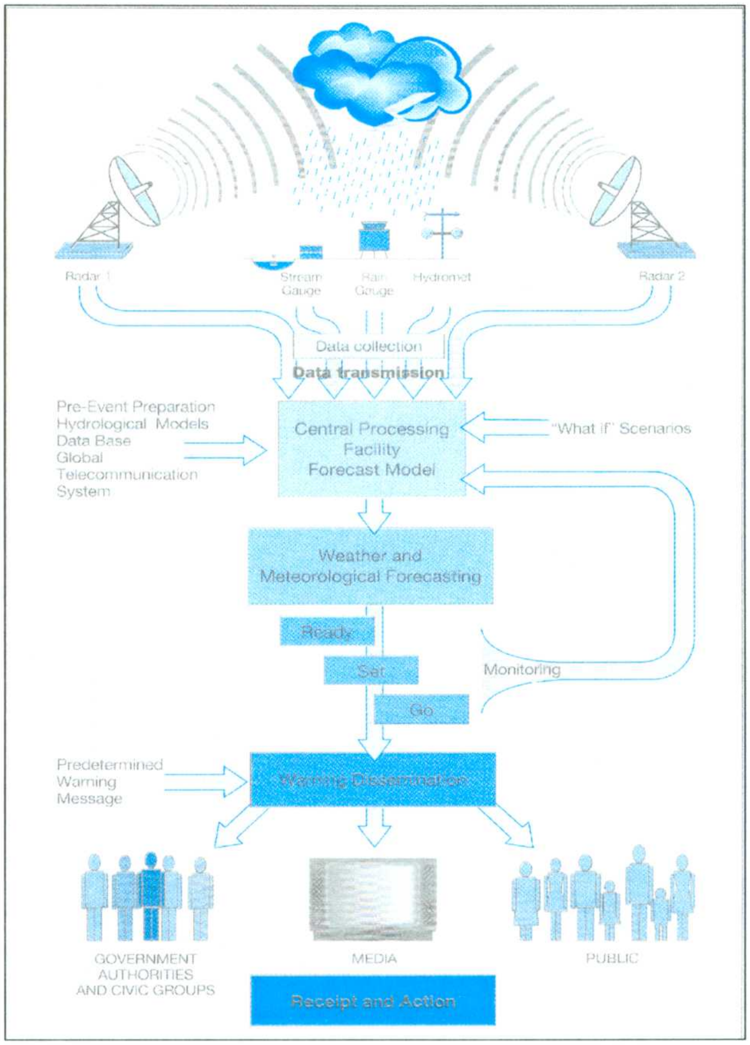


Figure 2.1: The major components of an Early Warning System as depicted by the World Meteorological Organization

Meteorological and hydrological warning starts with the detection of hazard or the precursor to its development, supported by weather data collection. Early detection of meteorological and hydrological hazards requires a network of weather observation stations. The weather data should be rapidly transmitted to weather centers for accurate and timely weather analysis and interpretation.

The latest technology on remote sensing has revolutionized the detection of hazards through the use of satellite imagery, which have added precision to the location and tracking of tropical cyclones and monitoring drought conditions. Remotely sensed images are also used to determine the spatial extent and intensity of precipitation. In addition, a network of weather radars has proven invaluable for tracking the development of weather disturbances like tornadoes and windstorms.

Globally, each day, some 20,000 weather observations (temperature, wind pressure, precipitation) are made at the ground surface, on ships, and in the air. These data are shared among national weather services and centers, and used for the preparation of daily weather analyses and forecasts. Currently, the low density and poor quality of observing networks in some developing countries presents a substantial barrier to improving the effectiveness of early warning. Subsequently the observational data from neighbouring countries becomes essential for the weather related hazard detection.

Early detection also requires an efficient communication system. For meteorological and hydrological hazards, the World Meteorological Organization provides a primary telecommunications network for the relay of observational data and related information within the meteorological community especially for the international exchange of weather data and information.

The prediction of meso-scale[7] hazards such as tornadoes severe thunderstorms, squalls and flash floods requires early detection, near instantaneous assessment of the threat and rapid dissemination of warnings to the population. The limitation of providing effective early warning for the meso-scale hazards is due to the short lead-time. The problem is more acute in developing countries that do not yet possess advanced or costly technology like Doppler radar and telemetry system for early detection and rapid dissemination of warnings to remote areas.

Prediction of droughts is very much dependent on monitoring the patterns of monthly and seasonal rainfall, stream flows, surface and ground water levels and soil moisture. Some progress has been made on reducing the lead-time by using the relationship between local weather and the ENSO phenomenon as an indicator.

2.1.3 Formulation of Warning Message

After the hazard has been detected or predicted, warning messages need to be drafted or synthesized. An effective hazard warning should contain the following messages:

- Characteristics of the hazard (time of detection, location, strength and speed of movement)
- Associated risk and the location of the population at risk (or an identification of the general area at risk
- Recommended appropriate action

In some regions, warning messages originate from multiple sources, often with contradictory content that confuse decision makers and the public. To avoid such confusion, all the warnings should be issued by the responsible national or regional meteorological center so that there is a single authority for hazard warning in a given area. A WMO expert group defines the meteorological warning as the official issued bulletin of that event (severe weather) produced by the responsible National Meteorological Services (NMS).

[7] Meso-scale hazards. Hazards that occur in a very short interval of time with a short lead-time for its detection (e.g. tornadoes, flash floods, squalls)

2.1.4 Dissemination of Warning

Successful hazard detection and predictions are ineffective if warnings are not disseminated quickly and communicated effectively to the population at risk. To benefit the public, a warning system must strictly meet two criteria: it must reach the public on time and it must be easy to understand. Dissemination of warnings should be managed well to ensure timely delivery of messages to the public. The first criterion requires an effective communication system while the second requires a sustained public awareness program.

Communication System: An effective communication system is a vital component of any effective early warning system. The effective dissemination of warnings to the public and local level disaster managers requires a communication system with a wide reach such as radio, television and community warning facilities. Reliance on exposed overhead telephones and power lines, and antennas leaves the communication vulnerable during windstorms. The local community warning systems such as sirens and loudspeakers are highly effective in these circumstances.

Public Awareness and Understanding: For a warning to be effective, not only should it be received with a sufficient lead time but should also be well understood by the target public and authorities, who in turn should believe the message and perform the recommended action. Understanding the warning content and reacting accordingly can be best achieved through supporting on-going public awareness of potential risks. Thus, authorities in charge of the early warning system should ensure that public awareness and education on warning are given high priority and adequate commitment of resources.

2.1.5 Community Response to Warning

The last, but perhaps most critical component of an effective early warning system is community response. Getting the public to react to warning in an appropriate manner is the biggest challenge faced by disaster managers at the community level. Developing and implementing an early warning system at the community level is the most complex of the components. Organizing the community to act as one in responding to threat is a live drama that requires effective orchestration, direction and a well-written script that is memorized by all the players. It requires a scenario that needs to be practiced to perfection.

Trigger events and hazard warning can prompt communities to take action for preparedness, increasing the safety of communities. Risk assessment plays a vital role in identifying what communities and which areas are most vulnerable to hazard, thus prioritising actions. In addition to the physical warning of an impending hazard, a vulnerability assessment creates order in the actual response to warning. Thus, vulnerability maps that are regularly updated serve as critical input in effective response to warning.

The conditions that need to be met for a community to act appropriately upon receipt of a warning include:

- Getting free warning and hazard information
- Receiving warning with sufficient lead time
- Understanding the warning content

- Believing the warning
- Believing that the threat is real
- Knowing when and what appropriate action to take
- Being in a state of preparedness

2.2 International Contribution to Hydrometeorological Early Warning

The international community has been instrumental in promoting the development of early warning systems as a priority strategy in the effort to reduce the impacts of disasters worldwide. In 1995, the United Nations General Assembly requested the IDNDR Secretariat to conduct a review of early warning capacities and to suggest ways and means by which global practices could become better coordinated and made more effective. One of IDNDR's original program targets was for all countries to have in place, by the year 2000, ready access to global, regional, national and local warning systems as part of their national plans. The International Strategy for Disaster Reduction (ISDR), the successor to the IDNDR, continues to maintain international momentum in the development of early warning capacity. Reports[8] produced through a range of expert working groups and international conferences outline key issues and specific recommendations to assist policy makers and disaster managers.

Regarding the technical aspects of early warning, substantial international infrastructure has been established to forecast weather and provide necessary observational data. Observational networks, prediction centers and telecommunication systems are standard components of existing infrastructure and are the cornerstone of any early warning system. At the global level, the World Weather Watch (WWW), Hydrology and Water Resources Programs coordinated by the World Meteorological Organization (WMO) provide a solid operational framework on which to build improved early warning capacity.

2.2.1 Weather-related Warning

The World Weather Watch (WWW) launched by WMO in 1963 is a global system for the collection, exchange and processing of weather data and weather information. The WWW has three main components that help the national weather services produce the weather forecast and cyclone warning. These components are the Global Observing System (GOS) that provides the observed weather data; the Global Telecommunications System (GTS) that relays observations, forecasts and other products; and the Global Data Processing System (GDPS) that produces weather analyses, forecasts and guidance.

Another important component of WWW is Regional Specialized Meteorological Centers (RSMC), which provide a range of diagnostic and prognostic products such as short, medium and long-term weather predictions. In Southeast Asia, the RSMC based at Tokyo provides the numerical weather prediction based on global and regional models and other diagnostic and prognostic forecasts to Cambodia, Indonesia, Lao PDR, Philippines and Vietnam. The information provided by the RSMC includes the formation, movement and development of tropical cyclone and associated meteorological phenomena. Figure 2.2 illustrates the flow of information from RSMC Tokyo to the National Weather Services in the countries included in the inventory, with the exception of Indonesia.

[8] http://www.unisdr.org/unisdr/warningreports.htm

The WWW also comprises of a well-coordinated system operated by the member government weather services. In the past few years, this system has also promoted the exchange of numerical weather prediction that helps in the preparation of daily weather forecasts and typhoon warnings.

The WWW also supports the Hydrology and Water Resources Program that facilitates and assists the worldwide network of flood forecasting systems operated by national hydrology agencies. The UNESCO International Hydrological Programme (IHP) complements WMO's Operational Hydrology programme through its focus on improving knowledge of hydrological processes, methodologies for water resource assessment and management and national capacities in related areas.

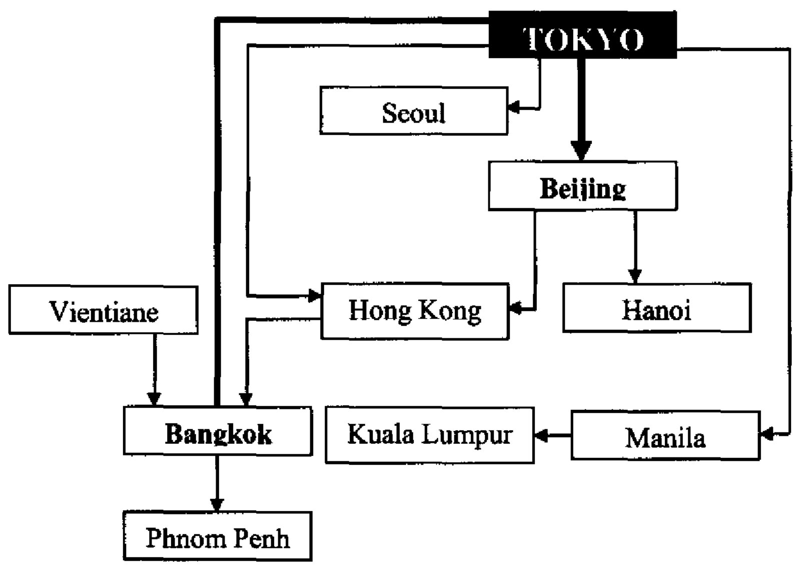


Figure 2.2. Information flow from the Regional Specialized Meteorological Center, Tokyo, to the National Weather Services in Southeast Asia

2.2.2 Flood Warning in the Lower Mekong River Basin

The Lower Mekong River Basin experiences regular flooding due to the enormous water flow during the wet season. The flooding results in extensive destruction but also provides livelihood by supporting productive and diverse freshwater ecosystem.

In response to the regular occurrence of floods in the Mekong region, the flood-forecasting and early warning operation for the Lower Mekong River Basin began in January 1968 as an area of intervention for the MRCS to take up regionally in parallel to the development of FMM strategy. Since then, forecasting operations using hydrologic models on a high-speed computer have been carried out during the wet season as one of the core activities of the Mekong River Commission Secretariat[9] (MRCS). For stations in the upper and middle reaches of the Mekong River, the forecasts for water level were made from one to five days in advance, while for the stations downstream the forecast ranges from one day to two weeks in advance.

The Mekong River Basin

The Mekong River originates high on the Tibetan Plateau. Six countries share the Mekong Basin: China, Myanmar, Lao PDR, Thailand, Cambodia and Vietnam.

At 4,800 kilometers (2,976 miles), the Mekong River ranks twelfth in the world in terms of length and eighth in terms of average annual runoff. The flow in the Mekong varies with the tropical monsoon climate. It begins to increase at the onset of the wet season in May, peaking in August or September, and decreasing rapidly until December.

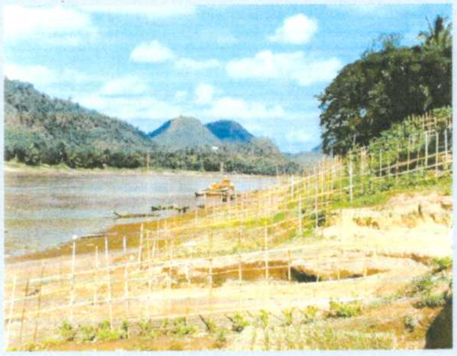


Figure 2.3: A section of the Mekong River in Northern Laos. The riverbanks serve as fertile grounds for growing vegetables.

Flood monitoring and forecasting

Despite the forecasting system being operational since last three decades, it was only after the great floods of year 2000 that the flood monitoring and management system was upgraded. The floods, one of the most devastating events in the Lower Mekong Basin, led to the establishment of the strategy on Flood Management and Mitigation (FMM). One of its objectives is a well established and fully operational, user-oriented regional flood forecasting and early warning system for the Mekong River Basin. Its specific objectives are to solicit appropriate responses from the public that includes:

- Alert people (especially children) at risk
- Encourage organizations and individuals to alert others, when at risk to the danger
- Initiate flood-proofing activities
- Assist farmers to decide when to harvest
- Trigger relocation to a safer shelter and gather emergency supplies
- Stimulate property-saving activities such as moving livestock, business stock, and household effects to a safer place
- Warn operational and relief organizations through a ready-set-go alert system
- Advise operational government staff to undertake operational tasks such as opening sluices/gates

Hazard detection and forecasting

During the flood season (July to November), data observed daily from major hydrological and meteorological stations within the Lower Mekong Basin are sent to the Secretariat at

[9] **The Mekong River Commission (MRC)** was established on 5 April 1995. Member countries are Cambodia, Lao PDR, Thailand and Vietnam. MRC maintains regular dialogue with the two upper states of the Mekong River Basin, China and Myanmar. Its predecessor, the International Committee on the Mekong River had done some work on the Mekong River towards development and helping the riparian countries deal with the annual flooding.

0700 hrs via radio. Using the most appropriate hydrologic models (the Secretariat employs hydrological modelers from the four riparian countries involved in the project to develop the most appropriate model for each country), the collected data is processed on a computer, and the forecasts for the water levels are made for one to five days in advance.

The results of the calculation are sent by facsimile in a standardized reporting format to the riparian countries through their respective National Mekong River Commissions. A sample of a five-day forecast is attached as Annex 5.

Warning messages and dissemination
At the regional level, the MRCS maintains a website where the current situation in the reporting hydrological stations on the Mekong can be accessed anytime. It illustrates warning levels in a format that is easy to understand (figure 2.4). If more detailed information is required for each reporting station, a schematic diagram showing the water level at any particular hydrological station can be accessed.

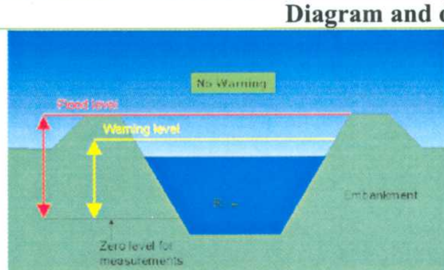
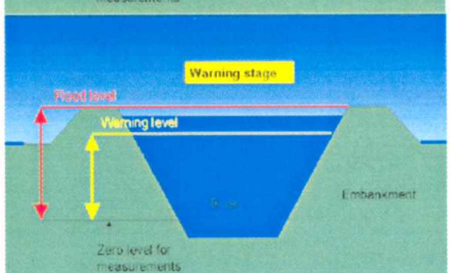
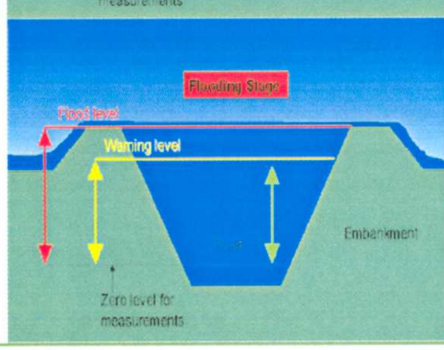
Warning level	Diagram	Description
No Warning		The height of the water, measured from the zero level (gauge datum) is below the alarm level. No risk of flooding.
Alarm stage		Water level is equal or higher than the alarm level but lower than the flood level. River water is high; threat to low embankments, flooding of low-lying areas.
Flooding Stage		Water level equal or higher than the flood level. All low-lying areas submerged, this can include low-lying areas in cities and towns; safety of river protection dykes in jeopardy; damage to infrastructure begins.

Figure 2.4. Schematic diagram and description of flood warning levels issued by the Mekong River Commission

The MRCS is progressing to improve the Early Warning System for the Lower Mekong River Basin. The improvements include:

a) Upgrading and improving the flood forecasting system at the MRC by using a mathematical model platform for flood forecasting and warning
b) Strengthening the forecasting capacity in terms of flood extent, duration and depth to meet wider ranges of requirements for flood preparedness, mitigation, and others
c) Coordinating flood forecasting with the activity of flood management and mitigation strategy formulation
d) Upgrading the flood warning dissemination system at the MRC by introducing warning dissemination and a program for public awareness

MRCS flood forecasting would show more intensive and focused attention on the following:

a) Improved coordination between national and regional forecasts
b) Incorporation of rainfall data in flood forecast models
c) Forecast for duration and level of flooding
d) Dissemination of data to the end user
e) Flood hazard mapping

Appropriate Hydrological Network Improvement Project, financed by AusAID, with proposed real-time telemetering system along the Mekong mainstream and the study financed by JICA on the Hydrometeorological Monitoring for Water Quality Rules in the Mekong River Basin provide vital contribution to the implementation of the project.

The next five chapters provide a description of the early warning capacities in the DIPECHO target countries: Cambodia, Indonesia, Lao PDR, Philippines and Vietnam. Some country chapters also provide cases of community response to hydrometeorological early warning. A case from Indonesia presents a community-based early warning system for floods.