UNIT 2 EARLY WARNING

Structure

2.0 OBJECTIVES

After reading this unit, you should be able to:

- know the difference between a forecast and warning;
- describe the concept of an End to End Early Warning System;
- understand the four components of an End to End Early Warning System;
- know how the various components of early warning are inter linked;
- get an overview of early warning system for Cyclone, Tsunami and Flood; and
- know some of the basic features of early warning.

2.1 INTRODUCTION

Natural and technological hazards often result in disastrous events that can profoundly impact societies. Hazards such as Flood, Cyclone, Tsunami, Epidemics etc. or human made events such as industrial accidents, gas leakages, and terrorism etc. have not only caused huge loss of life but also resulted in large properties damages. Regardless of how or where a hazard originates, warning are the means of reducing the risk of a disaster. The expression 'early warning' is used in many fields to mean the provision of information on an emerging dangerous circumstance where that information can enable action in advance to reduce the risks involved. Early warning systems exist for natural geo-physical and biological hazards, complex socio-political emergencies, industrial hazards, personal health risks and many other related risks. Nearly a million of people have been killed over the last decade in disasters caused by storms, drought, floods etc. While some material losses seem to be unavoidable especially in the case of large and infrequent disasters, in many cases the loss of life could have been avoided. This was amply evident during the Indian Ocean Tsunami 2004 which killed more than a quarter of million of people in many countries.

Forecast and Warning

The forecast generally is about predicting a future event such as rainfall, cloudy conditions, intensification of a low pressure system, stock market etc. A warning is different from the forecast in the sense that it carries a certain amount of risk information that requires protective actions. Thus each forecast need not necessarily be treated as a warning. For example a forecast such as moderate rainfall on the next day does not automatically qualify to be a warning its own. However if already

the rivers are in spate and a flood like situation is prevailing, forecast of a heavy rainfall can imply a warning. In essence, warning signifies a definite amount of risk to life and properties and therefore merit urgent attention.

There have been some debates recently about qualities which are essential for a risk message to qualify as a warning. For example, general forecast such as prediction of heavy rainfall, flooding or possibility of a terrorist attack etc. unless sufficiently backed up with more specific details such as which area, probable time of occurrence etc. very little action can be taken. In such a case should such risk information be considered as warning? This argument is mainly drawn from the usability perspective of risk information i.e. can action be taken on the basis of a warning. It also highlights the broad scope of the warning concept which often can go beyond the event forecasted or warned.

Early Warning

Early warning conceptually is the provision of early and relevant risk information on potential or actual disasters or their impact to vulnerable population. This constitutes one of the key elements of any disaster risk reduction strategy. It is important to note here that ***the ultimate goal of hazard forecasting and early warning is to protect lives***. An important debate in early warning studies centers around how early is early enough? Such questions arise mainly because of inadequate lead time available in case of some disasters which have severe consequences such as earthquake and landslides. For example, there have been some initiatives recently in establishing an earthquake early warning system in Japan by taking advantage of the travel time difference of primary and secondary seismic waves. Though there are reports of success in such initiative, there are also questions such as if a small available lead time can be useful for general public e.g. those who are in high rise buildings to take protective measures like evacuation.

Early Warning: A System Approach

A system is a set of interacting component parts that acts as a whole to produce an outcome. Systems thinking and methods have been very influential in improving the design and operation of many elements of modern society. Early warning systems can be likewise examined and improved from this perspective. The first step calls for a comprehensive framework of early warning system - of its desired outcomes, component parts, internal relationships, inputs and outputs - along with measures of its performance, preferably in relation to appropriate benchmarks or norms. The following four-element framework provides a good basis for defining early warning systems.

2.2 OVERVIEW OF END TO END EARLY WARNING SYSTEM:

Four Elements of Early Warning System: An effective Early Warning System comprises a chain of four elements, spanning the knowledge of risk faced, monitoring and warning services, communication and dissemination of warning messages, capability to act on early warning. Failure in any one these part will be failure of the whole system. This approach is generally called an end to end early warning system.

Risk Assessment

The risk assessment process which is basically analysis of various hazard risk e.g. identification of potential hazards, probability of their occurrence, their impact potential etc. precede the establishment of an early warning system. Unless these

hazard risks are not assessed systematically, it becomes difficult to plan for a warning system. To illustrate, a society or a particular geographical area face numerous hazard risk some of which may be infrequent like tsunami. However such infrequent hazard when it occurs can have serious consequences and therefore it is essential to give adequate attention to assess each of the probable hazard risk and develop consensus among scientists, government and public about need for establishing corresponding early warning system. Consequently, if any such hazard risk has not been identified or its impact potential has not been properly estimated, little planning will exist to forewarn when it occurs.

Another important dimension of risk assessment process is, it must recognize the differences in vulnerabilities that exist between different sections of societies and also the dynamic nature of such vulnerabilities. The risk due to hazards is not uniformly distributed and thus an effective Early Warning System need to be founded on appropriate Risk Assessment methodologies.

Detection, Monitoring and Warning Services

The detection, monitoring and warning service is at the core of an early warning system. Broadly speaking, this component is the domain of scientific and technological institutions. For example, in India, India Meteorological Department (IMD) is the nodal agency for providing Cyclone Warning Services, Central Water Commission (CWC) has a mandate for providing Flood forecasts, and Indian National Centre for Ocean Information Services (INCOIS) is responsible for providing tsunami warning. (See related Box) Similarly Ministry of Agriculture provides forecast about drought in India and National Institute for Communicable Diseases, Ministry of Health and Family Welfare is the nodal agency for giving warning and advisories about epidemics. These agencies employ variety of tools and instruments to detect corresponding hazard, monitor such hazard from its detection level to track its growth, use various scientific models to construct future scenarios and accordingly if required forewarn all concerned and issue advisories or warning. The warning information that is to be communicated to the vulnerable population must be user-friendly. Specific attention must be given to this aspect, especially to avoid scientific or technical terms which warning recipients may have difficulties in comprehending.

Communication of Early Warning

The warning once generated are then communicated or disseminated to all vulnerable population. A large number of communication or dissemination tools or choices are available. While communication process generally emphasizes a two way information transfers allowing the listener of warning to speak back, dissemination signifies a one direction flow of information. Two ways communication is generally desirable; however, many times dissemination mechanism such as radio serves an important function and is often the only communication choice available to reach out to a large number of vulnerable populations.

There can be a range of technological solutions to communicate Early Warning to the vulnerable population and it is necessary to have such choices which are accessible and robust. Some of these communication tools which are used for early warning are; Radio, Television, Newspaper, Telephone especially the mobile phones which are continuously increasing its coverage area and penetrating into different segments of societies, Very High Frequency (VHF)/High Frequency (HF) radio sets, VHF based Siren-Loud Speaker systems, Internet, Satellite phones, Fax, Satellite based radio and warning dissemination services, HAM radio, Radio Data System (RDS) etc. The communication component of early warning system also includes hardware support which is essential for many the above communication mechanisms for example, radio or television services, satellite coverage for the

area. Each of the above communication tools as a carrier of early warning information has both advantages and disadvantages. Factors such as lead time, coverage, topography of the area, access to warning devices, cost, maintenance, reliability etc. need to be taken into account while designing the early warning communication mechanism. As a rule, multiple redundancies are always recommended so that failures of a selected communication channel do not jeopardize the entire early warning system and thereby put the vulnerable people at life risk. To reach out to the last person and avoid failure, a combination of such communication mechanism and technologies should be used.

Last Mile Connectivity: One of the lessons learned globally during recent past is that in spite of the major advances in information and communication technologies during recent times, large number of vulnerable people continue to have no access to early warning and do not receive timely warning. Various studies conducted have shown that while communicating early warning to national government, state or provincial government has become much easier; the same is not the case for local level communication/dissemination. For example, in India during any warning phase, while there is multiple communication channels available to reach to the concerned state or district agencies or in come cases up to the block head quarter, communicating a warning to each of the village and informing all within the village at the time of emergencies remain a major challenge. Unless the last vulnerable person is informed during a warning period in a timely manner, there will continue to be loss of life and the chief objective of early warning system is not fulfilled. Considering these aspects, internationally there is a drive towards emphasizing adequate communication capacity at local level known as "***Last Mile Connectivity***". Often local monitoring of hazards and warning procedures such as Sirens, Drums, Signs, Lights, loud speaker mounted on a vehicles, Bells etc. have been found to be the most effective at the time of emergencies and such methods need to be recognized, supported, and integrated in the overall Framework.

Response Capabilities

The component of response capabilities emphasizes that the recipient of warning e.g. community, public authorities etc. should have the capacity to act on the received warning. This refers to that those who receive warning have the capacity to interpret it properly, have the means to take protective actions as recommended. For example, people in the coastal areas unless have a safe shelter to move to, warning them for a cyclone and tsunami may not result in the desired outcome.

a) Risk Assessment	b) Detection, Monitoring and Warning Services	c) Communication and Dissemination	d) Response Capability
Prior Knowledge of Risk faced by the Communities	Technical Monitoring and Warning Services for all such risks	Communication of Understandable Warning to those at Risk	Knowledge and Preparedness to act
Risks arise from hazards and the vulnerabilities that are present: What are the patterns and trends in these factors?	Is there a sound scientific basis for predicting the risks faced? Are the right parameters being monitored?	Do the warnings get to those at risk? Do people understand them? Do they contain useful information that enables proper response?	Do communities understand their risk? Do they respect the warning services? Do they know how to react? Do they have the means to act?

A range of activities can be planned to enhance response capabilities. This will be based on the specific type of hazard-warning, recommended protective actions such as for evacuation there may need to be construction of safe shelters, identification of other safe buildings, road communication, transport facilities, provision of drinking water, sanitation, food, medicines, provision for accommodating cattle and poultry, security etc. Capacity building at the community level need to be planned to ensure that systematic preparedness programs have been conducted, that disaster management plans are in place and have been tested, and that community members have been adequately trained to know how to act after receiving Early Warning.

Integrated System: Effective Early Warning Systems have strong linkages among all the above four elements. To serve people effectively, early warning systems must be integrated and link all actors in the early warning chain including the scientific and technical community, public authorities, and local communities. Risk scenarios are constructed and reviewed. Specific responsibilities throughout the chain are agreed and implemented. Past events are studied and improvement made to the Early Warning System. Manuals and procedures are agreed and published. Communities are consulted and information is disseminated. Accurate, timely, reliable, and comprehensible communications are essential. Operational Procedures such as Evacuations are practiced and tested. Effective early warning procedures should be part of the national institutional and legislative framework for disaster management. They equally need to have redundancy built into the system. Early warning must be complemented by professional services, training, and capacity-building activities and the allocation of resources to enable timely actions to be taken to avert loss.

Check Your Progress I

Note: Use the space provided for your answer.

1) What is the difference between a forecast and warning?

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2) Describe the four components of an Early Warning System.

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2.3 EARLY WARNING FOR CYCLONE, TSUNAMI AND FLOOD

Cyclone Warning System in India

India Meteorological Department (IMD) provides Cyclone Warning Services for the country. The cyclone warning organization of IMD has a three tier system to cater to the needs of the maritime States and union territories. These are, Cyclone Warning Division set up at IMD Head Quarters New Delhi to co-ordinate and

supervise cyclone warning operations in the country. Area Cyclone Warning Centers at Chennai, Mumbai and Kolkata and Cyclone Warning Centers at Visakhapatnam, Ahmedabad and Bhubaneswar. The cyclone warning services is also supported by the Forecasting Division at Pune.

Monitoring of Cyclones: IMD has a network meteorological observatories consisting of automatic weather stations (AWS), radar and satellite systems covering the entire coastline. The satellite techniques (INSAT imagery obtained at hourly interval) are used to find out the centre and intensity of the system. The radar can be utilized to find out the location of the cyclonic storm more accurately when the system comes within radar range (approx. 400km). In addition, the radar data also helps in estimating other parameters such as convective cloud cluster, wind distribution, rainfall rate etc.

Track and intensity prediction: Tropical Cyclones move as a whole. The average speed is 15-20 kmph (360-480 km per day). The cyclonic system may change their direction of movement and intensity. Various Techniques are available for Track Prediction of the storm such as; methods based on climatology, persistence Synoptic Techniques Satellite Techniques, Statistical Techniques using climatology, persistence and synoptic, Analogue Techniques, Numerical weather prediction models etc. Similarly techniques like Climatology, Synoptic and Satellite (Dvorak) techniques and radar techniques are used for predicting intensity. Numerical Weather Prediction models are also used for intensity prediction.

4-stage warning system for Tropical Cyclones: Since pre-monsoon cyclone season of 1999, IMD has introduced a 4-Stage warning system to issue cyclone warnings. They are as follows: (1) Pre-Cyclone Watch- Issued when a depression forms irrespective of its distance from the coast and is likely to affect Indian coast in future. The **pre-cyclone watch** is issued at least 72 hours in advance of the commencement of adverse weather (2) **Cyclone Alert:** Issued at least 48 hours before the commencement of the bad weather and when the cyclone is located beyond 500 Km from the coast (3) **Cyclone Warning:** Issued at least 24 hours before the commencement of the bad weather when the cyclone is located within 500 Km from the coast. Information about time /place of landfall is indicated in the bulletin. Confidence in estimation increases as the cyclone comes closer to the coast. (4) **Post landfall outlook:** It is issued 12 hours before the cyclone landfall, when the cyclone is located within 200 Km from the coast. More accurate and specific information about time /place of landfall and associated bad weather indicated in the bulletin. In addition, the interior distraction likely to be affected due to the cyclone is warned in this bulletin.

Disaster Management: In a case a depression develops over north Indian Ocean, Bay of Bengal or Arabian Sea special bulletins at-least three times a day are issued to Control Room of National Disaster Management Division (NDM), Ministry of Home Affairs, New Delhi. When the system intensifies into a cyclonic storm, the cyclone warning bulletins are issued every three hour. When the system weakens or not going to affect Indian coast, a de-warning is also issued to NDM Control Room. The cyclone warning bulletins are also passed on to All India Radio, Television channels, Central/State Government Authorities/District Collectors who are in constant touch with Cyclone Warning Centers.

Flood Forecasting and Warning in India

A nationwide flood forecasting and warning system is developed by Central Water Commission (CWC) and this initiative has also been supplemented by various States/UT that make special arrangements for strategically important locations in their states. The forecasts can be of different types such as forecast for water level (stage forecast), discharge (flow forecast) and area to be submerged (inundation forecast). The forecast when carries definite risk information is called warning.

The flood forecasting services involve collection of hydrological data (gauge, discharge), meteorological data; rainfall. In India hydrological and meteorological data from over 945 stations in 62 river basins are collected and analyzed. While most of the hydro-metrological data are collected from the CWC field stations, IMD provides the rainfall data from their rain gauge stations besides providing synoptic situation for heavy rain fall for the next 24 hours.

The various data from different locations are communicated to CWC flood forecasting stations on real time basis using wireless communication such as Very High Frequency/High Frequency sets in addition to telephone/telex/Fax/V-Sat/ Internet etc. During the flood situation, data is transmitted two to three times a day but the frequency is increased to every hour if the flood situation so demands.

Historical data like gauge, discharge and rainfall are used in conjunction with computer based models and sophisticated mathematical models to issue two types of forecasts; stage and inflow with time of occurrence. These two types of forecasts are issued whenever the river stage at the flood forecasting site exceeds or is likely to exceed a specified level called warning level which is decided in consultation with concerned state government. The warning level is generally one meter below the danger level at the site although there is no common format designed for this purpose. The final forecasts are then communicated to different user agencies such as concerned administrative and engineering department of Central/State government, District Administration, Public, Media e.g. All India Radio, Television channels etc.

Tsunami Warning System in India

In the wake of massive loss of life during the Indian ocean tsunami of 2004, a tsunami warning system has been now established by the Ministry of Earth Sciences (MoES) in collaboration with Department of Science and Technology (DST), Department of Space (DOS) and the Council of Scientific and Industrial Research (CSIR). The National Tsunami Early Warning Centre has been set up at Indian National Centre of Ocean Information Services (INCOIS), Hyderabad.

Tsunamigenic zones that threaten the Indian Coast have been identified by considering the historical tsunamis, earthquakes, their magnitudes, location of the area relative to a fault, and also by tsunami modeling. The tsunami early warning system comprises a real-time network of seismic stations, Bottom Pressure Recorders (BPR) and tide gauges to detect tsunamigenic earthquakes and to monitor tsunamis.

The tsunami early warning centre receives real-time seismic data from the national seismic network of the Indian Meteorological Department (IMD) and other International seismic networks. The system detects all earthquake events of more than 6 Magnitude in the Richter scale occurring in the Indian Ocean within less than 20 minutes of its occurrence. Bottom Pressure Recorders (BPR) installed in the Deep Ocean are the key sensors to confirm the triggering of a Tsunami. The National Institute of Ocean Technology (NIOT) has installed 4 such BPR in the Bay of Bengal and the 2 BPR in Arabian Sea. In addition, NIOT and Survey of India (SOI) have installed 30 Tide Gauges to monitor the progress of tsunami waves. Integrated Coastal and Marine Area Management (ICMAM) has customized and ran tsunami model for historical earthquakes to predict inundation areas. These community-level inundation maps are extremely useful for assessing the population and infrastructure at risk. INCOIS has also generated a large database of model scenarios for different earthquakes that are being used for operational tsunami early warning.

Communication of real-time data from seismic stations, tide gauges and BPR to the early warning centre is very critical for generating timely tsunami warnings. A

host of communication methods are employed for timely reception of data from the sensors as well as for dissemination of alerts. Indian Space Research Organization (ISRO) has made an end-to-end communication plan using INSAT. A high level of redundancy is being built into the communication system to avoid single point failures. The early warning centre established at INCOIS is equipped with necessary computational and communication infrastructure that enables reception of real-time data from all the sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure. Seismic and sea-level data are continuously monitored in the Early Warning Centre using a custom-built software application that generates alarms/alerts in the warning centre whenever a pre-set threshold is crossed. Tsunami warnings/watches are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, following a Standard Operating Procedure. The efficiency of the tsunami warning system was proved during the large under-sea earthquake of 8.4 M that occurred on September 12, 2007 in the Indian Ocean.

The National Tsunami Early Warning Centre is to communicate Advisories to the Control Room of the Ministry of Home Affairs for further dissemination to the Public. For the dissemination of alerts to control room at MHA a satellite-based virtual private network for disaster management support (VPN DMS) has been established. This network also enables early warning centre to disseminate warnings to the State Emergency Operations Centers. In addition, Messages are also to be sent by Phone, Fax, SMS and e-mails to concerned authorized officials.

Check Your Progress II

Note: Use the space provided for your answer.

1) What is the four stage cyclone warning provided by India Meteorological Department (IMD)?

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2) What are the elements involved in preparation of flood forecast of Central Water Commission? Which are the two types of flood forecasts issued?

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2.4 SOME BASIC FEATURES OF EARLY WARNING

Early warning and response are interrelated. One is of little effect without the other. To questions such as why do people respond differently to the same warning, why is there different perception of risk and why do warning agencies sometime fail in eliciting desired action from vulnerable population, social science research have begun from 1950's and considerable insights have been derived from such

studies. Response to warning can occur at different levels e.g. individual, family, community etc. Most current studies attempt to model the effect of a complex set of factors and their interaction on warning response. Some of the key features of early warning are given here.

Source of the Warning

A warning source is the entity or agency responsible for initiating warning communication and it can be government agencies, media figures, or friends and relatives etc. Warning originating from credible sources is likely to promote warning compliances. Further, the population warned will be normally heterogeneous and there will be different sub groups within such population who will receive warning from different sources. These sources may have varying credibility and trustworthiness and accordingly there may be difference in response.

Warning Message

A warning message should provide some basic information such as date and time of issue, source, validity period of warning, targeted audience for whom the warning is intended, location of phenomena and the likely impact areas, recommended protective action, availability of the next warning-time, source etc. In general terms, the warning message should describe about who should do, what, when, how, with whom, why and with what consequences. Clarity of the message and specificity are important attributes attached to early warning. For example, it may not be sufficient to say simply that a dam will break. To facilitate response it must give the height and speed of impact of flood water that will ensue, size and location of the area that can be affected. Certainty and accuracy is generally sought in warning message, however in some cases it may not be possible to provide fully accurate forecast due to several factors such as lack of scientific data, inadequate understanding of the phenomena etc. Another important feature of early warning message is that it should be consistent both internally and externally.

Warning Communication Channels

Warning can be communicated through broadly voice, signals or printed mediums. Voice can be direct like personal notification for example telephone, door to door, very high frequency radio etc. or indirect such as broadcast over radio, television etc. These mediums have their inherent strengths and weaknesses for example radio or television warning will find it difficult to warn a much selected audience, similarly signals have to be interpreted correctly. Permanent warning signs or sirens/ alarms are sometimes used for remote locations and in such case people must be made aware about meaning of these signs and sirens and what to do during such times. Often more than one channel is used for early warning and the choice of a channel or channel mix should depend on the hazard under consideration and characteristics of population to be warned. The selection of channel should consider factors such as amount of information needed to communicate the hazard risk, amount of information each channel is capable of carrying and time available.

Frequency of Warning

Frequency or the number of times a warning should be repeated is best dictated by the need of the situation. The frequency should be ideally geared to the dynamics of emerging risk and severity. During any warning phase, people constantly want updates on the risk even when there is little change in the hazard status.

Receiver Characteristics

The public response to early warning varies and depends on a number of factors and the information contained in warning interacts with various personal attributes of recipient. These include warning belief or determining that a threat exist, sense

of personal risk or to what extent the predicted event will affect individuals, family etc. When people receive a disaster warning their perception of risk is often shaped by their pre-existing beliefs in the likelihood of its occurrence. Similarly, the characteristics of the disaster agent can have significant influence on public response. People can have different level of awareness and familiarization about various hazards and prior experience of a hazard can affect individuals' assessment of the risk and pre- disposes their likelihood of taking a protective action. The demographic attributes such as gender, income, education, social role, age, ethnicity etc. can be some of the factors in determining response to an early warning.

2.5 LET US SUM UP

The concept 'early warning' is used in many fields to mean the provision of information on an emerging dangerous circumstance where that information can enable action in advance to reduce the risks involved. The realization over the last decade is that simply focusing on any particular aspect of early warning such as hazard detection or communication does not ultimately serve to achieve the objective of an early warning system which is to save life and try minimizing properties damages. Thus an end to end early warning system should be considered comprising of four components which are risk assessment, detection-monitoring and warning services, communication of warning and response capabilities. These components are interlinked and failure in any one of the above component will lead to failure of the system. An important concept in early warning is last mile connectivity which emphasizes local level warning dissemination so that the last vulnerable person has access to early warning. Some of the basic features of early warning include credibility of the warning source, message clarity, specificity of risk e.g. location, time, impact description etc. selection of communication channels, frequency of warning and receiver characteristics.

2.5 FURTHER READINGS AND REFERENCES

1) Wogalter, M.S. (ed.) (2006). *"Handbook of Warning"* North Carolina State University Press.

2) Zschau, J and Kuppers, A. (ed.) (2003). *"Early Warning System for Natural Disaster Reduction"* Springer Verlag, Berlin.

3) Drabek, T. (1999). *"Understanding Disaster Warning Response"* Social Science Journal, Vol. 36(3): 515.