2. Early Warning Systems

Wherever practicable, people must be made aware of an impending disaster in advance. This will give them time to prepare themselves for leaving their homes for safer areas. Many natural phenomena are predictable. It is possible to issue early warnings to the people likely to be affected by the event. Such warnings help to reduce loss of life and property.

A comprehensive early warning system has the following objectives:

- to inform the public about likely risks
- to forecast in advance and communicate to all concerned about impending disasters
- to ensure speedy actions in communication and response
- capacity and resilience building in the community for the expected risks

The deficiency of early warning systems at the international level was observed during the Indian Ocean tsunami in 2004. The submarine earthquake and resulting tsunami affected 14 countries. Due to the absence of an early warning system, there was huge loss of life and property. The tsunami itself was unavoidable. But many lives could have been saved if there was forewarning of what was to come.

Early warning, however, is not restricted to warning about impending disasters alone. The early warning system should ideally consist of:

(a) Hazard and vulnerability analysis for a region; this will give a comprehensive idea about the risks the population is likely to be subjected to

(b) Continuous monitoring for early detection of impending disasters and issuing the necessary alerts to the public

(c) Developing a communication system and flow of communication such that public and disaster responders are immediately informed of the developing situation

(d) Making efforts for capacity building for the identified risks in the community

An early warning system thus has actions spanning across many phases of the disaster management cycle. Detecting a disaster using technological tools and scientific analysis is definitely an important part of warning or issuing alerts. More important may be the pre-disaster warning based on hazard and vulnerability analysis and getting the community to prepare for it.

6.4 MITIGATION

Mitigation refers to all the measures taken to reduce the risk from disasters. This can be done through many actions that are aimed at increasing the capacity and resilience of the individuals and community. A number of steps like hazard mapping, vulnerability analysis, building codes for structural mitigation, alternative economic models to prevent economic vulnerability, etc. are required. Personal mitigation is a key to national preparedness. Individuals and families are trained to avoid unnecessary risks. An assessment of possible risks to health and property is made and steps are taken to minimise the effects of a disaster.

The objectives of mitigation are to:

(i) Reduce the risk due to natural and man-made disasters

(ii) Take steps like hazard mapping and vulnerability analysis for risk management

(iii) Prepare and enforce structural mitigation measures like building regulations and their implementation

(iv) Reduce risk by exercising control over development

(v) Help vulnerable populations putting in place measures for crop planning, urban planning and land use regulations.

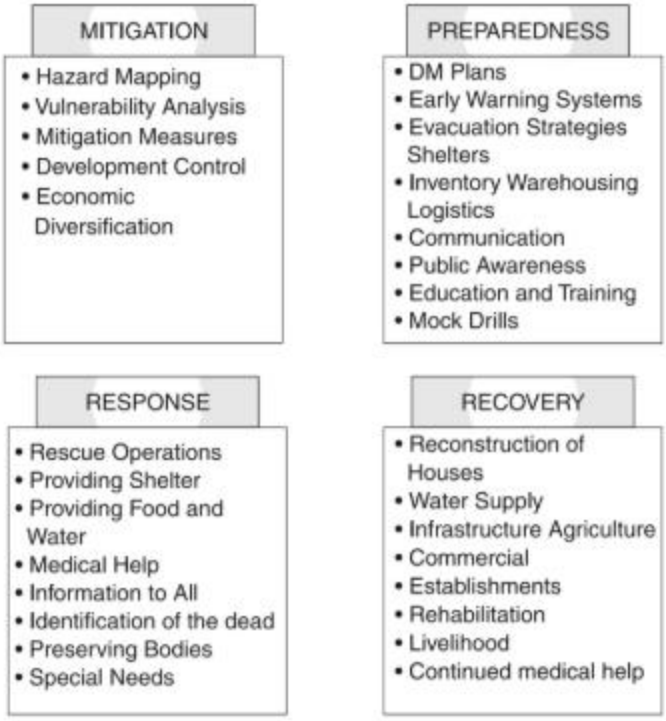

Figure 6.2 Detailing of disaster management phases

1. Hazard Mapping

A hazard map shows the hazard likely in a region. To prepare a hazard map, data is required about the hazards that have happened in the region in the past. This is obtained from essentially two sources.

(a) Recorded history

For the last many decades, records of hazards that have occurred in different regions of the world are available. These are being compiled in many countries for the purpose of disaster mitigation. Such records give an indication of the likely hazards in a country or region.

As an example, Chile is a country subjected to multiple hazards. This narrow strip of land lies between the Pacific Ocean in the west and the Andes Mountain range in the east. There are a number of active volcanoes in the region, and it is also frequently subjected to very severe earthquakes. The country is in the Pacific rim and so is exposed to tsunamis and floods. In addition, there also can be landslides. Chile is thus subjected to multiple hazards. Based on its history, a hazard map has been prepared for Chile.

(b) Information gathered from the community

Where records are not available or insufficient, it is necessary to talk to the people living in the region who may remember the hazards they themselves have faced or have heard about from their elders.

From these two sources, a hazard map can be developed and marked in a map of the state or region. All countries have tried to develop such maps in recent times.

A hazard map has basically two objectives:

(i) To make the people of the region aware of the hazards likely in the region

(ii) To help disaster managers and other stake holders to plan and be prepared for the disaster as and when it occurs.

Generally, a hazard map is made to identify the regions affected by a single hazard. The hazard maps shown in Appendix 1 are for different types of hazards for the whole country. There is one map for earthquakes, one for floods, etc.

Individual States also have prepared maps indicating the hazards for their States.

Some people recommend multiple-hazard maps. These are considered beneficial because one hazard may lead to another of a different type. For example, an earthquake can cause landslides and avalanches, the bursting of a dam may lead to floods and so on. A hazards map showing the multiple hazards that a region may be subjected to, may be of great help in taking preventive measures.

From the data collected on past hazards, what we get is a hazard records map. A scientific analysis of this data together with other studies like geological data, terrain features etc., is required to forecast the possible disasters for prevention and preparedness measures.

2. Vulnerability Analysis

We have discussed vulnerability and its four types—physical, economic, social and environmental.

Risk is a function of hazard and vulnerability.

i.e., $\text{Risk} = f(\text{Hazard, Vulnerability})$

Vulnerability depends upon many factors. When hazard mapping is done, the likely hazards are known. We can look at vulnerability and its various types from these hazard maps.

(i) People living in low-lying areas are vulnerable to floods from heavy rains or tsunamis.

(ii) People living near coastal areas are vulnerable to flooding due to high tides, tsunamis, cyclones and heavy rains.

(iii) People living on hill slopes or at foothill areas are vulnerable to landslides and avalanches due to heavy rains, earthquakes, etc.

(iv) People living in the flood plains of rivers are vulnerable to flooding due to the river breaching the banks caused by heavy flow from rains. The threat increases with time as the silt carried by rivers reduces the depth of the waterway thus causing flooding.

(v) People who live in homes not constructed to withstand earthquakes or built with wrong materials and methods are in danger of injuring themselves or losing their lives.

(vi) Among those threatened, the elderly, children and women are more vulnerable.

(vii) People without resources, like the poor, are more vulnerable.

The vulnerability analysis thus gives us a picture of the risk that people or regions may be subjected to and to focus on those aspects where vulnerability increases the severity of a disaster.

3. Mitigation Measures for Buildings

Mitigation measures for buildings are essentially aimed at preventing damage and fatalities due to earthquakes. These are generally referred to as structural and non-structural mitigation measures.

(a) Structural mitigation

Structural mitigation essentially means ensuring that houses, offices and other commercial buildings can withstand the likely disaster. In many countries, even though some of building regulations exist, it has been found that the implementation of such regulations was limited to big cities and for high-rise buildings. The large casualty figure in rural areas during and after earthquakes is due to faulty building construction. Even in the Latur earthquake, buildings made of stones, weakly cemented together gave way during the earthquake, bringing the roof down and trapping people under debris.

Structural vulnerability is also high among the poorer sections of society who live in flimsy homes such as thatched-roof huts of fishermen. Their houses generally get damaged and blown away during a cyclonic storm.

While in big cities, buildings are designed and constructed according to building regulations like the Building Code of India, the concept of such resistant buildings should also penetrate in rural areas.

The concept of structural mitigation may also include those structures which have not collapsed but suffered minor damage during an earlier disaster. Structural retrofitting is done to strengthen the structure to make it adequately resistant to future disasters.

Countries should evolve regulations for buildings and sufficient build-in safety measures for the hazards the region may face.

(b) Non-structural mitigation

Non-structural mitigation can be considered as having two components.

(i) A structure, like a multi-storey building, has load-bearing components such as slabs, beams, columns and foundation elements. Walls, partitions, parapets, sun shades etc., are non-load bearing components. Failure of a non-structural component will not result in the collapse of a building.

(ii) Within the building, there are many components like electrical systems (such as ducts for wiring, light fitting), AC ducts, fire-protection systems etc., which mainly add load to the structure (are not load bearing). Then there are amenities like tables, chairs, beds, cupboards, wall mountings etc., which are added as comfort components for functionality.

Mitigation done for those elements other than structural load bearing elements is considered non-structural mitigation.

(i) All non-structural components must be adequately fixed to avoid their falling off, due to vibration, during an earthquake. External elements like parapet walls, stone or tile facings need to be appropriately braced so that they don't fall off due to vibration. False ceilings and suspended ducting etc., must be adequately secured with nuts or screws.

(ii) If there are wall-mounted elements like ACs, they need to be adequately anchored to the wall to prevent their falling off and injuring people.

(iii) A cupboard, for example, can fall off during an earthquake and injure people. It is advisable to fix them to the walls. Most of the other interior elements like tables etc., tend to move due to vibration and must be secured. Many chairs are on rollers in plush offices and will run on the floor if not secured.

(c) Mitigation infrastructure

The major aspects of infrastructure are communication and transport. During a disaster, we will generally not know what kind of damage will be caused to the infrastructure and what will be available. The communication part of the infrastructure is discussed in the next chapter.

Generally, one uses the road network and transport vehicles for evacuating people, transporting relief material, medical (ambulance) services etc., which are crucial in a disaster situation. Many times, after a disaster, such road network may be damaged by landslides or flooding making relief work difficult. Alternative road networks or means of transportation must be designed as a mitigation strategy for making transportation possible.

In coastal areas, the construction of sea walls must be undertaken to prevent water entering homes of people living in low lying areas during high tides or due to storm surge.

4. Control over development and economic activities

The government should have policies and practices in place for:

(a) Land use for various purposes. Control over land use for residential and commercial purposes must be stringently implemented as a mitigation measure, using the hazard mapping and vulnerability analysis.

(b) Agricultural crop patterns: Crop patterns must be studied and farmers advised to grow the kinds of crops that can withstand the impact of a disaster likely in the region. Where agricultural income is the sole source of finance for families, they will lose their livelihood in addition to their monetary loss due to disasters.

(c) Alternate income schemes must be made available for people in case they lose their livelihood, including insurance schemes and similar means.

(d) Critical infrastructure must be ensured to save the heavy economic loss due to disasters.

(e) Water resource management schemes must be implemented to save water and to avoid flooding. Rivers that carry large quantities of silt lose their water capacity over the years and must be de-silted to bring back the waterway to its normalcy capacity.

(f) Building houses in flood-planes must be avoided, industrial activity in flood areas also should also be contained, or such industries must be chosen that the economic loss in case of a disaster is minimum.

(g) Constructing houses and commercial buildings on hill slopes is highly risky and must be approved based on thorough geological studies only. This activity is generally undertaken after cutting trees from hill slopes and clearing the site of vegetation. This can cause severe landslides.

As an example, in the case of Uttarakhand, which depends heavily on pilgrimage and tourism for its economy, many hotels and other infrastructure were constructed after clearing hill slopes. During the cloudburst and the resulting floods, most of this infrastructure was washed away. This is a case that brought out this aspect prominently for careful consideration of development managers.

We now look at some examples for mitigation in different fields.

(i) Construction of dams and embankments

Construction of dams and embankments is necessary to irrigate land, for power generation and also to provide drinking water to the population. Dams and embankments also help to reduce the severity of floods. They are constructed at huge cost for the benefit of many. However, there is also a negative aspect of such infrastructure.

A dam displaces thousands of people from the habitat that they have been living in for many years. They lose their homes as many villages are likely to be drowned due to the water body created by the dam. These people also lose their livelihood as the familiar

environment in which they live and survive no longer exists. The massive water body also drowns many square kilometres of forest area, destroying the flora and fauna of the region. The environmental damage can be huge. While rehabilitation of such people is promised, this has been a weak link in the chain with many people not getting the right kind of compensation to restart their lives.

In the case of Sardar Sarovar dam on the Narmada River, the following data speaks for itself:

- *Dimensions*: Length 1210 m; height 163 m from the lowest point; Gross storage 0.95 million hectare metres
- *Benefits*: Irrigation facility to 1.8 million hectare metres covering about 3400 villages; drinking water availability to about 8215 villages; power generation of 1450 MW
- *Downside of the project*: 245 villages affected; 37,533 hectares of land submerged, of which 13,385 hectares is forest land; 40,727 families displaced.

The effort to rehabilitate people has been quite unsatisfactory in this project.

(ii) Land use

The pressure of population and economic development has altered the land use pattern over the years. It is easy to monitor land use with modern technology like remote sensing. Some points of concern are:

- Construction near river banks has become very common. All rivers have flood lines which are known based on experience. Two lines are generally drawn near river banks. One line indicates the area near the river banks on which no construction is allowed. A second line indicates the area within which temporary activities can be permitted. Encroachment near river banks has been a major problem. It is reported that one reason for the heavy flooding in Tamil Nadu in 2015 is the encroachment near river banks.
- Deforestation has been another major area of concern. Cutting of trees for various purposes like buildings on hill slopes has caused major landslides. This is also an ecological disaster because trees protect us from pollution.
- Construction of many buildings for housing and other purposes prevents natural flow of rainwater. With insufficient storm water drains, this acts as a trigger for floods in most cities in India. The recent flood in Gurugram is an example. When we construct buildings, it is imperative that we take care of means to drain rainwater safely from such areas.

Mitigation of Man-made Disasters

Mitigation measures are usually discussed with respect to natural disasters. But we should not forget that many man-made disasters cause equal havoc and damage. These disasters have been discussed in detail in Chapter 4. Mitigation (prevention) measures with respect to these should also be considered.

(i) Hazardous industrial units must be located away from city limits and dense human habitat. This also must take into account the possible expansion of city limits due to growing population. Sufficient infrastructure and facilities must be provided so that the industries do not suffer due to their remote location.

(ii) All industries must have safety audits conducted for their premises and processes. This must be made mandatory and government agencies must also check such audit reports.

(iii) Fire is a major hazard in all the cities. Fire prevention measures must be implemented in all industries and public places like cinema halls, auditoriums etc. Installation of fire and smoke alarms, water for extinguishing fires and other measures put in place must be checked frequently. Fire drills must be conducted regularly. Electrical short circuit is a major cause for many fires happening in India. Inspection and audit of electric supply infrastructure in public buildings must be undertaken regularly. Temporary electric connection given for specific purposes like school and social functions must conform to the standards stipulated for electric installations safety.

(iv) Design of transportation infrastructure like roads and railways must take into account stringent safety measures for their functioning. Considering the enormous numbers of road accidents and fatalities, it must be ensured that stringent road use control is enforced for the safety of vehicle drivers and pedestrians.

(v) Education and awareness about man-made hazards and the way people can contribute to the safety of human beings and infrastructure must be mandatory. This is the simplest way to prevent man-made disasters.

Response

1. Search and Rescue

Typically, in many disasters, this is the first step in response. As an example, in an earthquake, many people get buried under debris of their homes or other buildings. Some people may be alive under a collapsed building. Some of these people may survive if they are rescued and given medical help. Some people may be dead and it is necessary to remove those dead bodies as rotting bodies can become a health hazard.

Specialised teams are involved in search and rescue. While the local community can also help, we need trained response forces having the necessary equipment to do the job. Depending upon the geographical spread of the affected area, it may take time to reach the affected people. The transportation network may be damaged. In such situations, aerial search and location of affected people will be required. They may also have to be rescued by the aerial routes only.

The local community can be trained for some of these activities. The survivors will be the first responders in disasters. They can help many other people so that they survive. If a proper disaster management plan and operating procedures are laid out, the search and rescue work can take place fast.

2. Medical Care

An immediate requirement when rescue efforts are going on is medical help. Some people may have minor injuries that need first aid immediately. Some others may have serious injuries requiring hospitalisation. On-field care and ambulance services must be available. Many others may need heavy medication and surgical procedures to save their lives. All this will call for well-planned and organised medical services.

Many remote areas may not have facilities and equipment available locally. The patients will have to be shifted to nearby towns for healthcare.

Also, the dead bodies recovered will have to be taken care of till they are identified and disposed of by the next of kin.

It will also be necessary to monitor the health of survivors, particularly the children and the elderly, to avoid deterioration in their health due to living conditions.

3. Humanitarian Relief

With thousands of people displaced from their homes and having lost their resources, or unable to use them, humanitarian aid is a first priority. Shelter, food and water will be primary needs of individuals. In today's context, whenever and wherever a calamity strikes, it is found

that there is no shortage of help. Money and relief materials generally come in large quantities from nearby localities and countries around the world. The problem will be warehousing and logistics for distribution. Taking relief materials speedily to different locations has always been a problem. People subjected to traumatic experience crave for speedy relief. A proper disaster management plan and SOP (standard operating procedure) will help greatly in relief effort.

The other aspects of the response phase of disaster management are:

NGOs

The response phase is most likely the period when many NGOs will have to be a part of the relief work. Many times, NGOs will be the first responders when the disaster strikes as they will be nearby doing some socio-economic development work before and during the disaster. Their experience in humanitarian relief work will be valuable in disaster management.

4. Damage Assessment

During the response phase, many government and private agencies will be at many sites where damage has occurred. Loss of life and damage to private and public property has to be assessed. As in the case of the earthquake that struck Nepal, repeated aftershocks caused more and more damage as days passed by. There was damage to buildings, roads, and water supply and sanitation facilities. Such damage will have to be assessed and work started on priority on some aspects like water and sanitation for the health of the public. People can live in temporary shelters for some days, but they would like to go back to their homes as early as possible. Reconstruction efforts should start as early as possible.

5. Coordination

During the response phase in particular, with multiple agencies offering their help and present at many sites, coordination of efforts is a key factor. Setting up of a control room and identifying the person in command, as per the SOP if available, is a first step in coordination. For coordination of the response efforts, the following points are important:

- ***(a) Unified command:*** A person, most suitably a government official, should be identified as the person commanding the whole operation. He or she may delegate duties to others in case the geographical spread of the area is large.
- ***(b) Control room:*** The control room should be located conveniently so that the building in which it is housed is safe from the impact of the disaster. The control room should be manned 24 hours of the day with a good communication set-up to communicate with people at different locations. Key persons in command must be notified of all developments at frequent intervals as agreed upon.
- ***(c) Communication network:*** Communication network during disaster is of critical importance. Fail-safe communication set-up must be available all 24 hours. Normally satellite phones and internet facilities are used to have enough speed in the communication system. Failure in communication facilities becomes a serious handicap in response efforts.

6.8 STANDARD OPERATING PROCEDURE (SOP)

Every State, or region or country, has to prepare a Standard Operating Procedure (SOP) document to avoid confusion and increase efficiency of operations during the different phases of the disaster management cycle, particularly the preparedness, response and relief phase. The SOP is written by the government agency responsible for coordinating disaster management activities. The objectives of writing SOP are to:

- Provide a list of major executive actions to be taken by different agencies or departments in responding to, and to cope with disasters
- List the measures to be taken and persons responsible for preparedness, response and relief to the suffering population
- Inform in a concise and precise form, the actions expected of the different agencies and departments in each phase of the disaster and coordinate such actions from a central command
- Ensure effective coordination and communication between different agencies and people by stipulating communication protocols

In India, the NDMA has drafted the SOP for its functioning while each state has its own SOP in tune with the one by the NDMA. The following gives an idea about the content of a SOP document as given in the SOP by the NDMA and a state.

SOP is written for responding to natural disasters. As man-made disasters cannot be predicted, it is difficult to write their SOP.

The SOP generally covers all phases of disaster management such as:

The objectives of the EOC are to:

- Receive and process disaster alerts and warnings from nodal agencies and other sources and communicate the same to all designated authorities
- Monitor emergency operations
- Facilitate coordination among primary and secondary emergency support functions (ESFs), ministry/departments/agencies
- Requisition additional resources during the disaster phase
- Issue disaster/incident specific information and instructions specific to each concerned
- Consolidate, analyse, and disseminate damage, loss and needs assessment data
- Forward consolidated reports to all designated authorities

Control centres will also be set up at regional and State levels.

(b) Emergency Support Function (ESF): An ESF plan will be prepared at the national level clearly indicating the areas of responsibility of each of the agencies concerned that will provide mutual assistance in terms of resources, equipment, manpower etc. during disasters. The name, address and telephone numbers of nodal officers of the department/agencies will also be included in the plan. ESF plans will be reviewed from time to time.

(c) Incident Command System: ICS is a management system to organise various emergency functions in a standardised manner while responding to any disaster. Under ICS, an incident commander and officers trained in different aspects of incident management, such as logistics, operations, planning, safety, media management, etc., form a specialist incident management team and manage the disaster/emergency.

(d) Medical Preparedness: Every State Government will identify the hospitals, team of doctors and para-medics including mental health and psycho-social service providers at sub-divisional and district levels, who will be deployed at short notice. Their names, addresses, telephone numbers, mobile numbers, email IDs, etc. will be made available to the district and State control rooms. The list will be updated annually. The stock of medicines, accessories and equipment for each of the identified teams at the district and sub-divisions will be decided in advance as per needs.

(e) Resource Inventory: The Government of India has launched India Disaster Resource Network (IDRN), which is a web enabled resource inventory for disaster management. The state governments will ensure that necessary entries have been made in the web-portal and updated at least once in a month by the designated district authorities.

Early Warning Systems

The nodal agencies for early warning are listed as:

1. Indian Meteorological Department for Cyclone, Heat and Cold Waves
2. Central Water Commission for Floods
3. Indian National Centre for Oceanic Information Services for Tsunami
4. Geological Survey of India for Landslides
5. Snow and Avalanches Study Establishment for Avalanches.