NETAJI SUBHAS OPEN UNIVERSITY

Post Graduate Diploma in Disaster Risk Management

Paper 4 : National Hazards Risk Management

Paper 5 : Climate Variabilities & Disaster Risk and Urban-Rural Risk Management

Paper 6 : Industrial Hazard Risk Management

Paper 4
Natural Hazards Risk Management

Unit 1 ❒ DRM — A Recapitulation

Structure

1.1 What is Disaster?

The Centre For Research on the Epidemiology of Disasters (CRED) in Brussels, Belgium, uses the following definition :

‘‘A disaster is a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance.’’

1.2 What is Emergency?

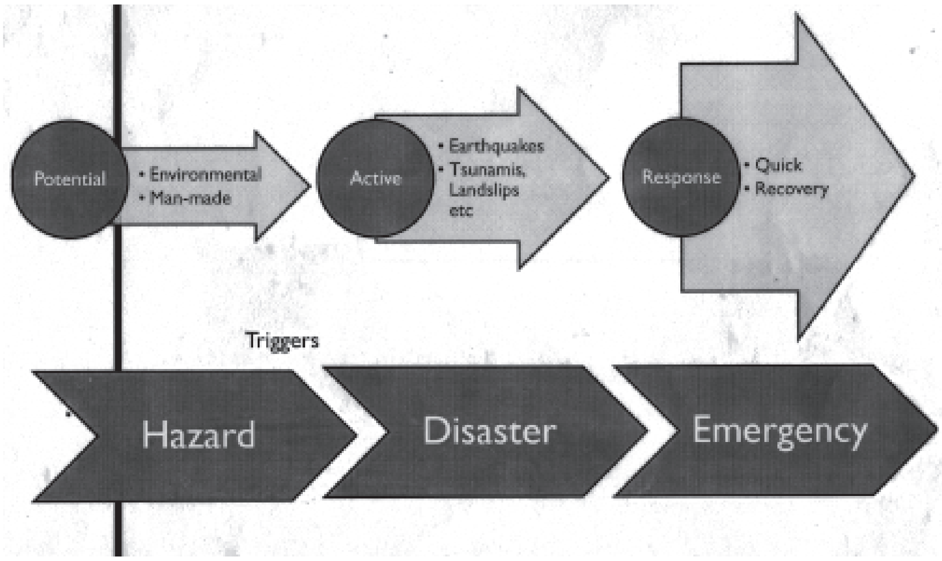
According to the definition in dictionary, Emergency is ‘‘an unforeseen or sudden occurrence, especially of a danger demanding immediate remedy or action’’.

1.3 Difference between Hazard, Disaster and Emergency

Hazards are situations, things etc which are potential threats to life, environment and society. They are dormant with a risk component (low tohigh risk) whichcan become active any moment due to relevant triggers.

Whereas, disaster is the impact of a natural or human-made hazard that negatively affects society or environment. Any man made or natural hazard having potential to cause widespread destruction of property and human lives is considered as a disaster. To common people, a disaster is a phenomenon or event that leaves behind a trail of destruction that also claims human lives.

Emergency refers to any situation that is threatening and requires quick response from you. When you see a risk to self, property, health or environment, you act hurriedly to prevent any worsening of the situation. However, there are situations that demand fleeing and no action on your part can help mitigate danger to life and property. Emergencies are of all scales and may affect a single individual to an entire population in area.

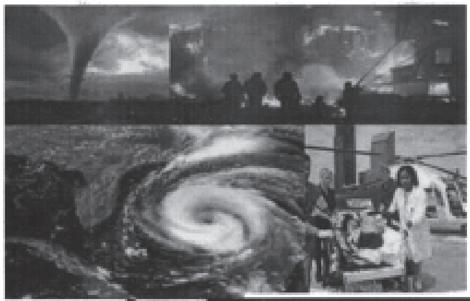


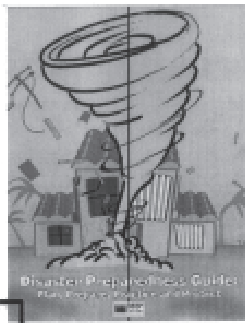
1.4 Disaster Planning

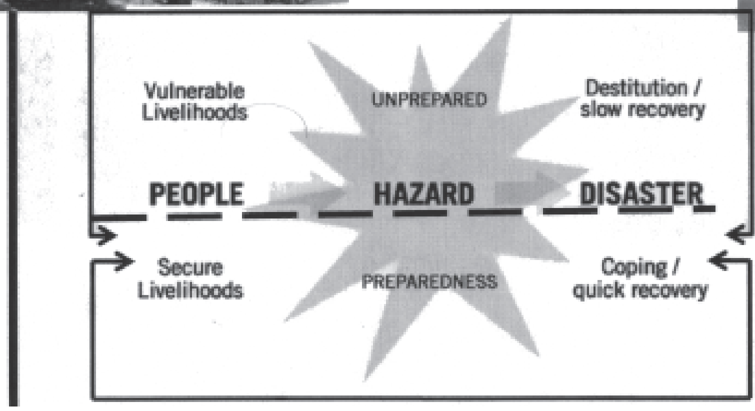
- What a Disaster Plan Is and Why You Should do One
- Possible Disasters
- Assign a Team—You Can't Create a Plan Alone (with family, friends, workmates)
- Analyze & Know Your Area/Organization/Neighbourhood
- Determine Your Critical Services & Functions
- Where is Your Information Stores
- Crisis Communications
- Emergency Planning Checklist

1.5 Disaster or Emergency Preparedness

- You are responsible to look after yourself
- Plan with your family & friends
- Don't stress while planning
- Plan in a way so that all members of the group or team remembers during the time Have a backup plan (Plan B & C)
- Plan realistically thinking that you would be on your own for first 48 to 72 hrs after disaster strikes
- Make it an important family activity so that every member recapitulates it from time to time and do not forget it
- Practice evacuation drill etc at least twice a year so that everyone remembers what to do Work together, work well







1.6 Disaster Management Plan (DNP)

Emergency planning is an integral part of the overall loss control program. It is important for effective management of an accident/incident to minimize losses to people and property, both in and around the facility.

1.6.1 Main Objectives for emergency Preparedness & Emergency Plan :

Emergency Preparedness

- To control events & prevent escalation
- To minimize the effect on people, property & the environment
- Effective rehabilitation of the affected persons.

Emergency Plan

- Reliable & early detection of an emergency & careful planning.
- The command, coordination & organization structure along with efficient personnel
- Resources for handling emergencies
- Appropriate emergency response actions
- Effective notification & communication facilities
- Identification of emergency isolation valves
- Proper training of concerned personnel
- Regular mock drill/rehearsal
- Regular review & updating of plan

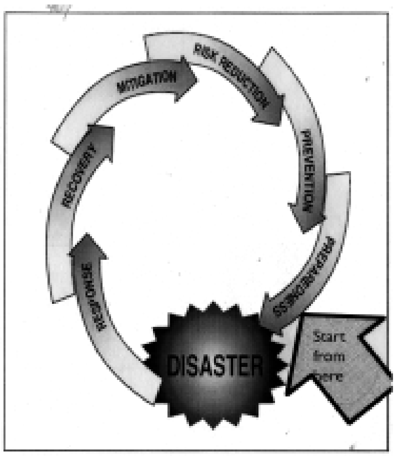
Civil Defence Emergency Management should be focused on **consciously planning and acting** to reduce social and economic impacts and improve recovery. Emergency management covers the '4 Rs';

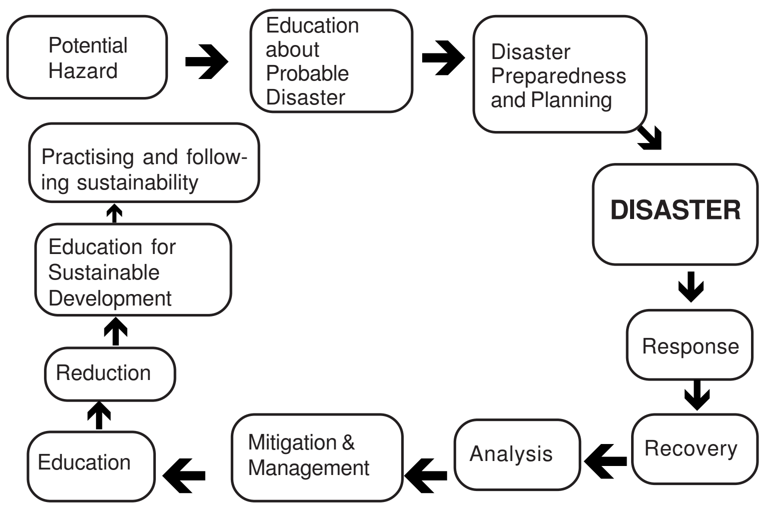
Reduction
Identifying and analysing long-term risks to human life and property from natural or man-made hazards, and taking steps to eliminate these risks where practicable, and where not, reduce the likelihood and the magnitude of their impact.

Readiness
Developing operational system and capabilities before a disaster happens. These include self-help and response programmes for the general public as well as specific programmes for emergency services.

Response
Actions taken immediately before, during or directly after a disaster to save lives and property, as well as help communities to recover.

Recovery
Activities beginning after initial impact has been stabilised and extending until the community's capacity for self-help has been restored.



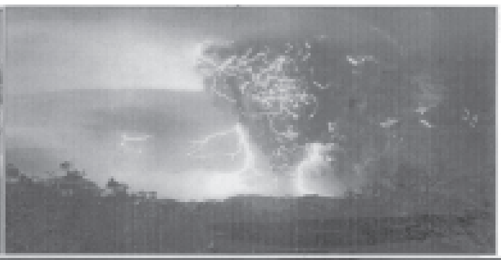


1.6.2 Disaster Control and Mitigation

- One cannot avoid the potential of disaster
- It is important that control and mitigation be sustainble
- Educating local people is imperative
- Knowledge brings resilience in the community and so does sharing of knowledge and learning
- Following and practising sustainability can give people an approach and attitude of control and mitigation

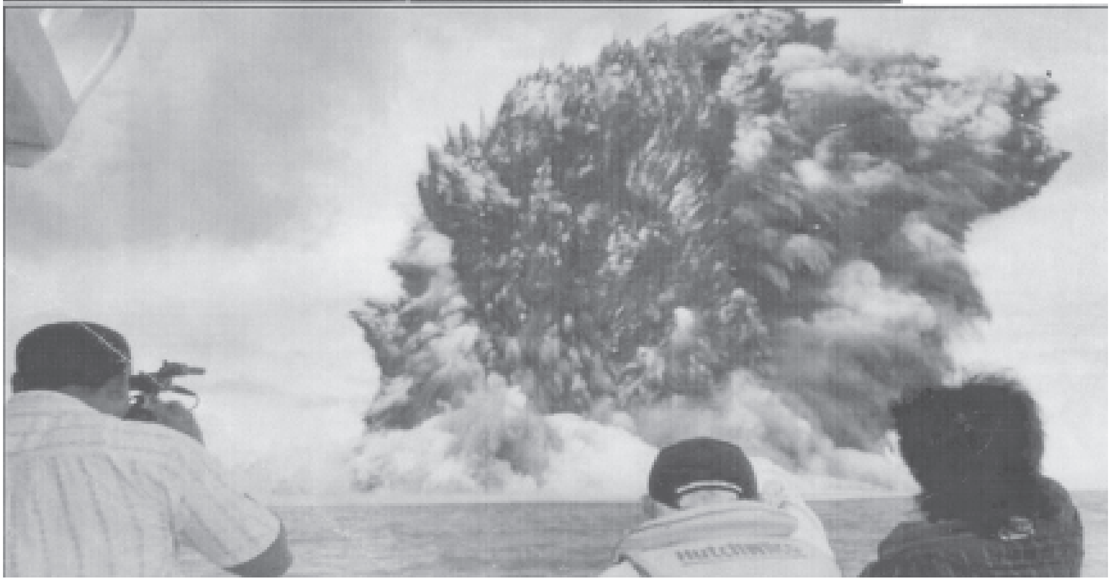
1.6.3 Social Interface and Building Resilience

- Education of local people
- Education from the grass root level
- Every single individual have the right to know about their environment and the potential natural disaster that the region might suffer from
- Media needs to play a big role in this
- All education institutions starting from day care centres or creche/kindergarten to tertiary level is responsible to teach students and itsmembers the life skills and impart knowledge about disaster planning and preparedness; sustainable development
- Educational education is IMPERATIVE and needs to be a continuous process



Disasters in different parts of the world

Avalanche and Rain/Storms



Volcanic eruption

Disasters in different parts of the world

Storm

Tsunami

Flood

Unit 2 ❐ Earthquake Risk Management

Structure

2.1 Introduction

Earthquakes are known as one of the most destructive natural disasters. Two characteristics of the earthquake are (i) nature of the event cannot be predicted in advance (ii) its frequency unlike other events generally occurs once in 5, 10, 20, 30, 50, 70 or 100 years or so.

The observation is that pre-disaster preparedness and mitigation measures are the only solution for earthquake risk reduction.

The question here is how to motivate an individual and or a community to take pre-disaster risk reduction actions.

2.2 Earthquake Risk and its Impact with examples

The Kobe earthquake of 7.2 magnitude in Richter scale in Japan in 1995 with a depth of 16km was devastating. The surrounding areas in the Hyogo prefecture was also severely hit. Casualty was enormous.

Dead > 6000 people

Temporary shift & shelter > 200,000 people

Building collapse > 70,000

> 50,000 seriously damaged

All city services including utility – totally disrupted

Fire broke out – 7000 building completely razed

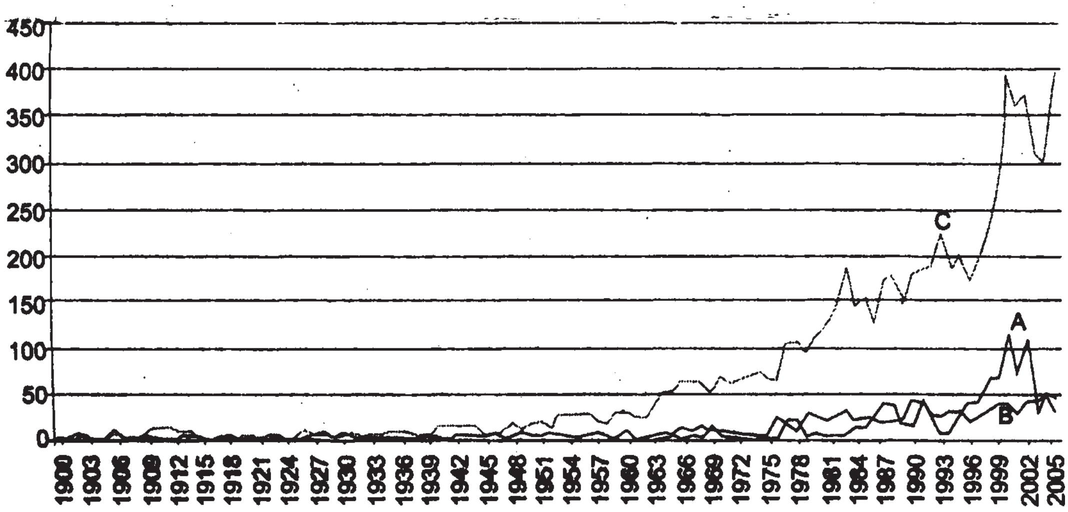
Burnt area > 800,000 sq. metres

Total damage to social & individual capital within Kobe city. – or 7 trillion Japanese 'Yen'. Secondary & tertiary losses in the city & surrounding areas – much higher.

Rescue – Evacuation by themselves (self help) – 60%

Evacuation by neighbors – 10%

Natural disasters — Trends



Table—Loss of human life due to earthquakes in the Indian subcontinent

Year	Locality	Death Toll
1839 (16 June)	Kachhchh (Gujarat)	15,000
1855	Badgam (Kashmir)	3,000
1897 (12 June)	Shillong (Meghalaya)	1,600
1905 (4 April)	Kangra (Himachal)	19,500
1934 (15 January)	Northern Bihar	10,500
1935	Quetta (Pakistan)	30,000
1950 (15 August)	Northeastern Arunachal	>1,500
1988 (21 August)	Udaypur (Nepal)	1,000
1991 (20 October)	Uttarkashi (Uttaranchal)	>1,500
1993 (30 September)	Latur (Maharashtra)	>9,000
2001 (26 January)	Bhuj (Gujarat)	>20,000

It showed that the effectiveness of the local people was due to

a) Information & knowledge of the community which helps fastest mobilization.
b) Leadership within the informal and formal community organization,
c) Availability of small tools for rescue operation such as saws and crowbars.

Similar phenomena were observed after the earthquakes in Marmara, Turkey in 1999 & Gujarat, India in 2001.

The role of volunteers like NGOs, DRM teams etc. however continues to be very relevant till some permanent arrangements are made in the locality. They are also very important in the dissemination of information among govt, non-govt. and international organizations. The other important factor in the development of interpersonal relationships among the affected people during temporary shelter days. In our country, volunteers must play a role to ensure that the people try to help each other as neighbors do.

In the earthquake of (2011) Sikkim, unfortunately, none was available for rescue operation immediately after the earthquake. Hence the effect was devastating. People were not aware of what was needed to be done i.e. what is meant by rescue was not known; neither the affected people knew what they should do. This lack of awareness in vulnerable regions of India is most distressing. The volunteers need to bear this in mind when they are contemplating earthquake risk reduction. It only emphasizes that a continuous groundwork is required for a long stretch of time to advise/instruct the denizens (and also discuss), before any earthquake takes place. Furthermore a community team should be organized who can shoulder the responsibility for future calamities.

Distrust & Lack of Co-ordination between Govt. Administration and the people

It must be ensured that sufficient assistance is provided to each victim. If not, things could be difficult. In Kobe even after 3 years of earthquake, urban infrastructure has been fully covered but victims, lives and livelihood were not. In fact often local governments' approved rehabilitation plans are different from what people want. In Kobe, a single track plan was prepared by the govt. for housing : shelters → temporary housing → permanent housing. There were significant gaps between commitment of resources and mobilization. A gap in understanding between the administration and the people can be seen in decisions related to urban planning after the earthquake and on the promotion of big projects like the Kobe airport. Such decisions led to distrust of people in the administration/govt. The reason for such a situation was because there was no partnership/ co-ordination between the administration and the people before the earthquake. While people were much dependent on the administration, the administration forced their decision on the people. Lack of communication between the victims and the administration led to the mutual distrust.

Motivating preparedness actions

- — approximately determine the loss of life due to possible earthquake as a function of building collapse, or landslide/search or rescue/emergency response, fire and/ or medical care problems.
- — Data collection when analyzed preferably using an algorithm indicates the relative severity of the area's earthquake risk, the sources of risk within each marked area and the relative effectiveness of potential mitigation options.

The indicators are :

Building fatality potential (Fig. 4.1) – to measure the groundshaking on firm and soft soils, the pillars or the base, the quality of building design, construction and materials, weight of building occupancy rates. Earthquake lethality potentials of different cities are shown in Fig. 4.2 and 4.3. Landslide fatality potential – to measure the groundshaking, ground condition, percentage of the city area likely to slide, the avg. annual rainfall, monsoon rainfall, population density of the area.

2.3 Search & Rescue life-saving potential

- — To measure the number of people available to participate in organized search and rescue and their training & effectiveness.

Fire fatality potential – to measure the degree of groundshaking, the amount of infrastructure damage, the annual average windspeed, the prevalence of flammable

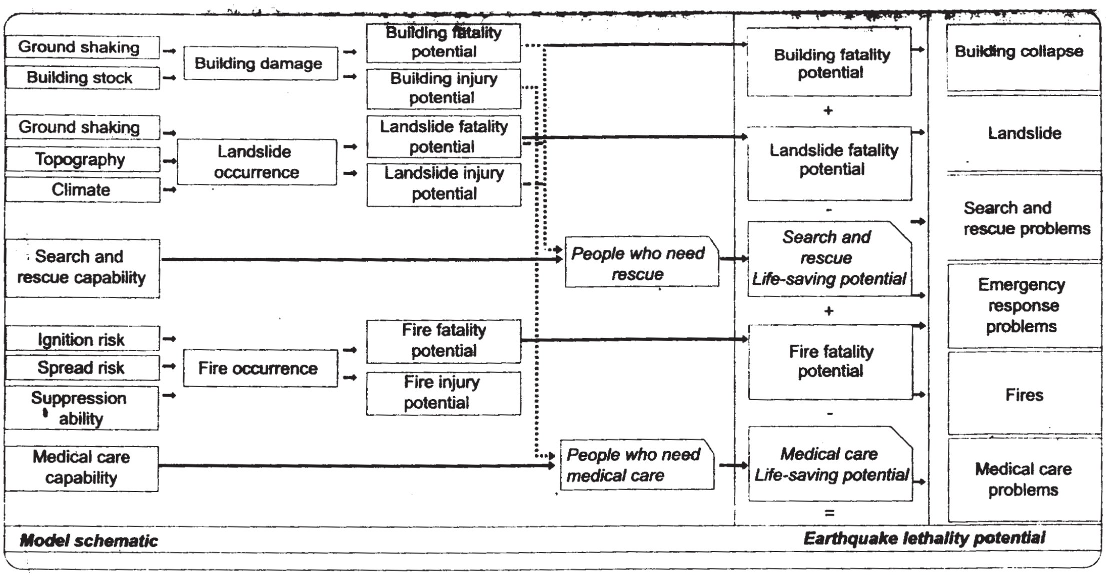


Fig.4.1 : Understanding of earthquake lethality potential.

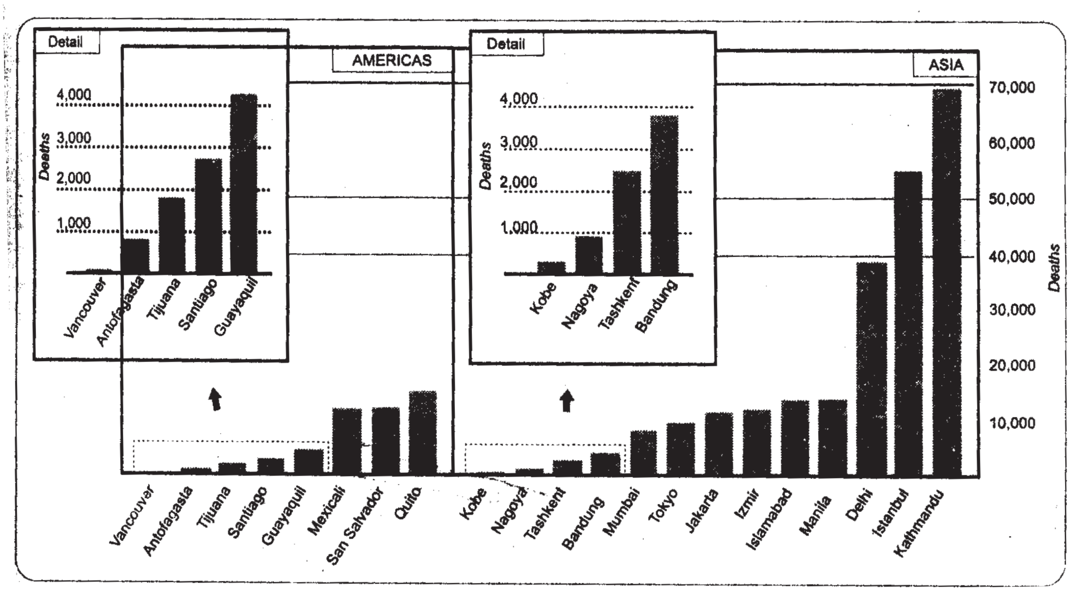


Fig.4.2 : Lethality Potential of the different cities incorporated from survey of Literature/reports

buildings & materials, density of structures, sources of available water, the ease of access to fire trucks and other equivalent, the water availability, the fire department's capability and the capacity of the locality to respond to emergencies.

Medical care or life-saving potential—to measure the capacity of the medical community in the area to handle casualties after the earthquake, (taking into account the possibility that the medical capacity might be reduced due to the earthquake).

It is recommended that local people should be familiarized with the data collection and this would help in risk reduction approach.

The total earthquake lethality potential in case of a severe earthquake (say 7 or >7) of Delhi 40,000 deaths

Kathmandu – 70,000 deaths

Mumbai – 10,000 deaths

The earthquake lethality potential in Delhi mainly arises from emergency response problems, medical care problems, lies and search and rescue problems in a descending order.

Post disaster recovery : Gujarat earthquake 2001 – 7.7 mag. >3000 deaths, thousands injured. Affected > 400 km stretch, 300,000 buildings collapsed see Fig. 4.3.

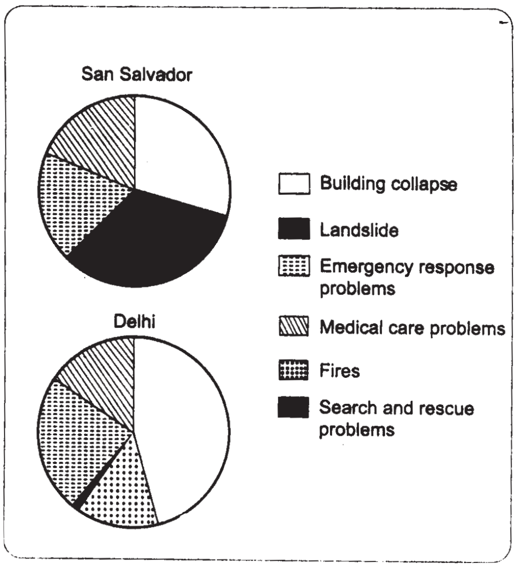


Fig. 4.3 : Comparison of the sources of earthquake-lethality potential in Delhi and San Salvador. (Adapted from literature survey)

For earthquake risk management Synthesis :—

1) To focus on community needs and priorities with specific emphasis on the socially vulberable groups
2) To bring communities in the decision making process
3) To reach a collective opinion of the communities

Mock Drill for Public

Mock means practicing of something that can happen in future so that any unforeseen consequences can be easily handled or dealt with. In earthquake risk management it becomes an exercise of implementing an emergency preparedness plan. Mock drill prepares the persons to face a disaster both mentally and physically.

Under mock drill, a perfect plan is obeyed and carried out so that each and every person in the locality is safely evacuated.

- Understanding of evacuation procedure is very important like a predetermined exit route must be known to the evacuees
- Drills offer the opportunity to identify training needs, establish new reflexes and teach through action, repetition and change in plan.
- Mock drills must be conducted 4 times a year.

Action pointers :

- Identify available open spaces that can be used as evacuation areas.
- Determine the shortest and safest route to the identified evacuation area. It can best

be done if mapping is carried out to mark the unsafe/vulnerable zones which may respond severely to the earthquake. The purpose is to avoid the response zones.

- Distribute and study the community earthquake evacuation plan in each household.
- It should be displayed in public places
- To orient community members on how to perform the "Duck , Cover and Hold" during a strong shaking. They (the communities concerned) need to know how to behave calm and in a disciplined manner during evacuation.

2.4 Prediction of Earthquake

It is not possible to predict the time, place and magnitude of earthquakes. This is an unattainable goal despite a few instances where successful predictions have been made. However, it is possible to identify an area likely to be hit by an earthquake in future. This can be done by critical study of seismic hazard-zoning maps and rigorous analysis of the trend and the pattern of geophysical and physiographic changes, specially in seismically locked segments. Events which could provide to the probability are —

i. There is a perceptible increase in micro-seismicity before major events. More than 40% of large earthquakes had foreshocks that occurred days and hours before disastrous events. This was observed in the case of the 1950 earthquake (M = 8.7) in the N.E Arunachal.

ii. One year before the earthquake event, development of cracks even on the ground surface may be initiated due to volume expansion of the rock body, as strain builds up. The volume expansion is evident from ground swelling and tilting of structures on the sloping ground (measured by tiltmeters).

iii. Radon gas progressively increases in quantity in the soil pore spaces, in rock fractures and in well water. Significant increase of radon in groundwater was noticed in the 1966 earthquake near Tashkent.

iv. The fracture and crack formation caused erratic fluctuation of the water table and deformation in the uppermost part of the crust. The water table goes down in some, arises in others. This happened in Arunachal Pradesh quite sometime before the 15th August 1950 earthquake took place. Likewise before the 1991 Uttarkashi earthquake there was an inexplicable and drastical change in the spring discharge.

v. Development of fractures and cracks allows groundwater to seep into the affected rock body and soil. The entry of water causes perceptible decrease in the electrical resistivity (Geophysics) and geomagnetic field (Geophysics) of the underground domain.

vi. Animals and birds are known to behave strangely before impending disasters like volcanic explosions and earthquakes. Dogs bark untiringly, agitated cattle and horses break away from their tether and run in circles, rabbits jump around with raised ears, rats and snakes come out of their burrows and holes and look quite dazed or stunned, terrified pigeons keep on flying and so on. The 4 February 1975 Haicheng earthquake of M 7.3 was predicted successfully partly on the basis of geophysical changes- particularly foreshocks and their temporal pattern and partly on the basis of anomalous animal behavior. Interestingly, a day before the 17 January, 1995 earthquake in Japan, sea lions and hippopotami in the Kobe Zoo showed strange behavior - they sank into their pools not to resurface. Likewise corcodiles in the Izu-Atagawa garden stopped eating; on the other hand, silkworms and fish aligned themselves in a common direction before the earthquake. This anomalous behavior has been attributed to fault movements associated with the earthquake.

Earthquake in all intracratonic region is well reflected by the Bhuj Earthquake (2001) of Gujarat from which lessons can be learnt in terms of the management of mitigation.

The Bhuj Earthquake in Gujarat, India in 2001 emphasizes that the structures on bedrock are more immune relative to those in sediments. If these lessons learnt from all accounts of various earthquakes since 1819 were included as a psot 1819 earthquake reconstruction guideline, damage in many areas in 2001 would have been reduced. Much of the severe damage in villages in and around Bhuj was the result of construction methods based on unreinforced, undressed masonary. Long-term legacy of the Bhuj earthquake need not only be one of tragedy if the seismological and earthquake engineering communities can exploit the available data and make use of the lessons learned. The Bhuj earthquakes provide an important opportunity to better understand and apprehend the hazard posed by earthquakes that occur in or affect intracratonic regions.

Unit 3 ❒ Flood Risk Management

Structure

3.1 Introduction

It aims at maximizing the net benefits from development in flood plains rather than minimization of economic losses. The world economy is increasingly becoming sensitive to climate. With the increasing frequency of extreme flood events and their changing impact (due to urbanization, deforestation, population growth, the potential climate change, rise of sea level), the number of people, vulnerable to devastative floods worldwide is expected to go up. Regular and extreme flooding in India specially, is the most taxing of water related natural hazards to life forms, socioeconomic activities, material assets (of the human kind), as well as to ecological and cultural resources.

Balancing development needs and risks is crucial. Mainstreaming flood risks into development process is therefore critical to achieving sustainable development. The latter may be achieved if we try to preserve ecosystem and their associated biodiversity. It helps to reduce vulnerability. It also helps to develop resilience.

Rising flood damage :

Damages resulting from flood are growing disproportionately. It is to be noted that (a) the frequency of major floods appears to be increasing because of climate change, particularly global warming and inappropriate development practices. (b) Secondly, there is a marked increase in the vulnerability of flood-prone areas due to the rising population and economic assets being located there itself.

3.2 Climate variability & change

The IPCC 4th assessment report says that there is strong possibility of increases in extreme climatic events like floods & droughts. It also emphasizes that the sea level rise due to global warming will induce coastal flooding.

Intense/heavy/severe rainfall events due to climate change which are observed to be increasing in frequency, will augment flood risk. There will be a pronounced effect of flood in coastal zone because of the population pressure there at. Climate change or climate variability predictions are uncertain. Thus their expected impact cannot be quantified. This makes decision making in risk reductions difficult.

Unprecedented demographic change, environmental concerns and integrated water resource management.

Exponential rise in the population in urban areas have resulted in an environmental change, worsening the situation. Expanding urbanization due to such pressure have resulted in sealing of the porous surface areas (soil) in the cities. Thus the hydrologic response in the risk-prone, low-lying catchment areas is changing, thereby increasing the intensity of flood hazards, more so in smaller catchments. Flood control and protection till recent times have been human induced i.e. engineering centred. It has consequently modified landsurface, channel network and waterflow regimes. These have ultimately enhanced the risk of disastrous consequences. It is now realized more and more that one cannot control flood, they being natural phenomena. There is a natural pattern in a river flow system vis-à-vis the land formation pattern there at. We need to adapt ourselves to this holistic pattern involving land and water by which we can protect the natural ecosystem and plan our economic and social developments. This could be coined as an Integrated Water Resource Management (IWRM). It is interlinked with the effective use of flood water during dry season.

Risk plays a pivotal role in IWRM since every element of water management involves decisions about level of risk bearing or risk reduction.

3.3 Assessing flood risks and its typology

Flood risk may be understood as a function of the

(i) Magnitude of the flood hazard expressed in terms of severity and frequency

(ii) Exposure of human life to flooding (depth, extent and duration of inundation and relative velocities)

(iii) Vulnerability of the elements at risk. (Vulnerability could be due to physical circumstances and due to socioeconomic conditions).

It may be relevant now to understand the term risk. Risk is the probability of harmful consequences or expected loss resulting from interaction between hazard and vulnerable conditions :

$$\text{Risk (R)} = \frac{\text{hazard x vulnerability}}{\text{Coping capacity}}$$

The definition incorporates exposure to the hazard as part of the vulnerability. Such a definition results in focusing on reducing exposure through human interventions/ engineering measures etc. Adequate attention can also be directed to look for options for flood-risk reduction, while tackling the socioeconomic vulnerability by economic interventions.

Flooding may occur due to the spilling of water out of the normal course from rivers, channels, lakes, overflow of urban drainage systems, accumulation of rain, rise in groundwater in coastal areas, storm surges, tsunamis, glacial lake outbursts, levee failures or dam-breaks. It is important to identify all potential sources of flooding. Related hazards initiated by the same causative elements like landslides, mudflows and debris flows also require identification. Understanding flood hazards and flooding requires :

- Geographic information System (GIS)
- Hydrological & meteorological analysis
- Hydrologic and hydraulic simulation of surface runoffs, floods and inundations
- Mechanism of flooding

With the aid of GIS, projected conditions of land use change, future developments in urbanization infrastructure are to be analysed. The future trends of hydrological and meteorological phenomena due to climate variability and change should also be comprehended.

It should be borne in mind that any change in the meteorological and hydrological phenomenon due to climate change and its variabilities must be analyzed and understood. It is important to note that any change in the meteorological impacts or the characteristics of the catchment area (this urbanization, infrastructure development) is likely to affect the hydrological magnitude and frequency of flood hazard. Any economic activity that comes in contact with flood waters is likely to be impacted adversely. The extent of the impact depends on the characteristic of the flooding in the exposed area, i.e. the depth, duration of flooding and the velocities of the flows. The concentration and type of the pollutants carried by flood waters also influence the intensity of impact.

Vulnerability of a community is its inability to anticipate, cope with, resist and/or recover from flood impacts. It can be a combination of physical, organizational and/or attitudinal factors. It is necessary to understand various contributing factors to vulnerability in order to carry out flood risk assessment.

3.3.1 Analysis and assessment of flood risks, its impacts and flood management.

Risk Assessment II

Risk assessment depends on its purpose. Usually it is carried out in 3 layers – short time, long time and futuristic. The approach could be regional, strategic and site specific. Method involves, characterization of risks both qualitatively and quantitatively. It is the process of determining the nature of extent of risks by analyzing the potential hazards. In addition it also evaluates existing conditions of vulnerability/adversity/capacity that could pose a harm to the community in terms of property, livelihood and the environment (which provides fresh air, drinking water and food).

The steps which provide assessment are :

Hazard assessment – identification of the hazard like flood in terms of depth, velocity and extent, estimation of the probability of flooding.

Impact assessment – assessment of likely damage – to number of people, to property, any secondary impacts.

Risk analysis includes risk evaluation, comparison of the risks, establishing acceptable levels of risks.

Flood hazard assessment, impacts, risk reduction options, risk sharing & transfer, uncertainty and — adaptive management :

- Know the sources → data collection and analysis.
- Work in conjunction with other related hazards like landslide, mudflow, debris flow
- Hazard assessment to be presented in the form of flood hazard maps to organize the information correctly, information on the past record, its impacts, the potentiality of damage and its impacts. These help to make decisions in flood management aspects. Some other functions of flood maps are :
  1) Regulatory – land use regulation and building codes
  2) Spatial planning – impacts of urbanization, other land uses and climate change
  3) Rescue operations – building shelters and making escape routes
  4) Flood insurance
  5) Vulnerability/adversity index

The impact assessment embraces three aspects – environmental, economic and social. Estimation of potential flood losses in terms of human habitat, industry, agriculture, infrastructure & fatalities are within the ambit of impact assessment. Such an estimation is inevitable to strike an optimal balance between the development needs of a particular area and the levels of flood risk, community is ready to accept.

All the major factors – flood magnitude, exposure and vulnerability that determine the risk must be understood (Fig. 4.5). How the flood risk scenarios change (climate,

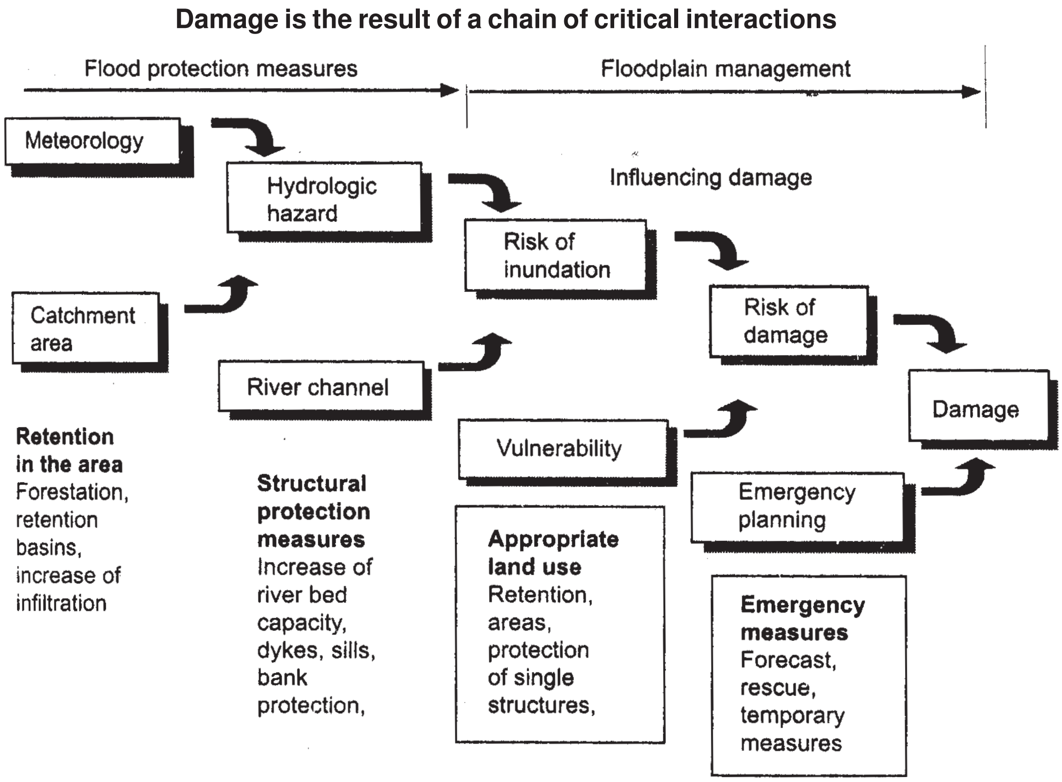


Fig. 4.5 : Typology of flood risks.

economy, infrastructure) with various development alternatives, what are the uncertainties need to be analysed. This is because they are important steps in flood risk assessment. Such risk criteria however change with time.

Additionally, it is important to establish threshold of risks that are economically viable to implement and is socially acceptable. Events that exceed thresholds are termed residual risks. Levels of safety that are provided to various economic activities (like agriculture, industry, urban development) depends on the amount of risk being faced. It will be determined by the current development conditions and future spatial planning.

Flood risk management involves reductions of risks, transferring the risks, sharing the costs of accepting the risks and ultimately living with the risks. Successful management implies that all the stakeholders have had proper understandings and perceptions of flood risks.

It is important to minimize the gap between the perceived risks and the actual risks so that rational decisions for risk management can be taken. This is possible if communication among the denizens, the NGOs and the administration at all levels is appropriate. It calls for flood map containing necessary information. In this sector help of GIS is recommended.

Options for reducing flood risks are shown in Table 1. These options should be in tune with national development policy and environmental policy and should be an appropriate mix of structural and non structural measures.

Pattern of sharing the cost of taking the risk among different levels of the govt., from the central through the provincial to the panchayat level, the community level and if possible even the individual level would determine the options.

Table 1 : Options for reducing flood risks

Reduce hazard	Reduce exposure	Reduce vulnerablity
• Retaining water where it falls (increasing infiltration, roof-top storing) • Retention basins (natural wetlands or depressions, man-made, e.g., school play-grounds, household under-ground tanks • Dams and reservoirs • Diversion channel • Land use management (e.g., house building codes in urban areas, infrastructure building practices, appro-priate spatial planning)	• Structural measures on the river (dykes, river control structures such as flood walls, raised infrastructure such as roads and railways) • Structural and non-structural measures/ actions by individual (floodproofing) • Land use regulations • Flood emergency meas-ures (flood warning and evacuation)	• *Physical:* by improving the infrastructure, well-being, occupational opportunities and living environment • *Constitutional:* by facilitating equal participation oppor-tunities, education and aware-ness, providing adequate skills and social support system • Motivational: by building awareness and facilitating self-organization

There are inherent uncertainties in various inputs that determine the risks, both at the hazard assessment stage as well as at the impact assessment stage. These are all the more emphasized because the existing knowledge available of the ecosystems is fragmentary and the implications of status of ecosystems are hence not understood.

As per the 15th principle of Rio Declaration on Environment and Development, in addition to the comprehension of the surrounding ecosystems, a precautionary approach should be widely applied by states according to their capabilities for environmental protection.

Adaptive management approach is recommended to tackle the uncertainties through incremental implementation of development plans.

3.4 Integrated Flood Management (IFM)

The principle emphasizes on management of flood instead of on controlling of flood. IFM encompasses flood risk management and synthesizes the principles of IWRM & disaster risk reduction (Fig. 4.6).

It involves the following action pointers :

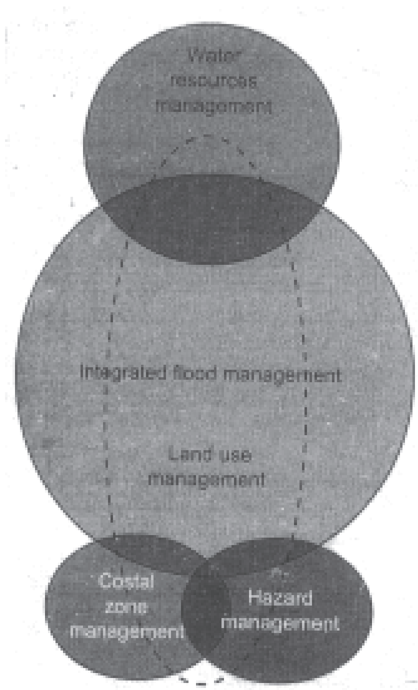


Fig. 4.6 : Integrated flood management model.

1. To adopt a river basin approach to flood management. That means you have to take into account the whole river system (river basin as a whole) when planning for managing floods.
2. To bring a multidisciplinary approach to flood management.
3. To reduce vulnerability and risks of the communities involved due to flooding.
4. To address climate change variability and make efforts to adapt to the changing scenario.
5. To check the influence of floods on groundwater recharge. This becomes an important source of water during the dry season and drought.
6. To enable community participation in the management programme. Involvement of administration, volunteers, NGOs & the community is essential.

The main theme of IFM is to consider the river basin as a dynamic system. In the dynamic system there are many interactions and fluxes between land and water bodies. The measures take a full account of the impact of land use and spatial planning on the flood generation process. Thereby land and water management are integrated. To achieve the result of IFM, there is an appropriate need for legal and institutional framework for collaboration and coordination between different levels of the Govt. entities and flood management planning. Where a compromise has to be made between development and ecosystem preservation needs, it must be based on an environmentally sensitive framework.

Recommendations for control of flood fury — the Uttarakhand (India) experience:

1. Appropriate Flood Risk Assessment in the river basin with special reference to the specific region is a must which was missing in Uttarakhand.
2. Understanding of the extent of vulnerability of the population. In India, majority of population (80%-90%) is vulnerable to disaster. And 27 states/provinces out of 35 total states in the country are prone to disaster. The vulnerable zones in each province requires delineation and arrangements must be made for reconstruction and rehabilitation, in time.
3. In India, 7.21 million hectares on an average go under flood water and are ravaged by the water. Projects on proper drainage, unplanned building construction (unscrupulous development) whenever one wants to setting up of ecozone etc. along with the National Flood Commission recommendations (1980), nearly 80% of India's flood prone areas could be provided with a reasonable degree of protection.
4. Disaster Management Boards in the states or in the country should be manned by experts who have experienced disasters. Ecologically sensitive provinces like the Himalayan states, coastal states like W. Bengal experienced Disaster Management Cell should be a top priority.
5. Forest cover in any zone particularly in the Himalayas should have been protected; instead, it has been depleted leaving the sensitive zone more vulnerable to disasters.
6. When building dams as in Uttarakhand, it should be borne in mind that the ecological cycle is not hampered.
7. Unfortunately ecology is considered much less important than economy. But in reality, economy depends on the health of ecology.
8. Industrialization turns ecologically sensitive regions to fragile and zone create havoc. As for example when sand is removed from the river bed in excess, it hampers river flow systems, hence there is an harmful impact on ecology. There should be a strict state mechanism to control the proposed and measured industrialization. Since environment expresses quantum interconnectedness, the approach to be adopted is the ecological approach emphasizing the importance to ecology. In the long run, the Himalayas would not suffer alone, the entire country is the total river basin will suffer (speaking with reference to the Ganges). In the present case, unplanned development, rampant filling of trees and series of dams in Uttarakhand — all man-made are responsible for such a scale of disaster —
   (a) Series of dams has allegedly upset ecological cycle and hill slope stability.
   (b) Depletion of forest cover has loosened soil, leading to landslides which are frequent.
   (c) No urban planning to house constructions in geologically danger zone.

3.5 Climate Change Polity for Disaster Prevention — The West Bengal Exemplar

Barring barely 1% of its area in mountainous north and 6% in the western plateau fringe, West Bengal is primarily composed of a flat alluvial plain, a large portion of it being a part of the Gangetic delta. This vast flood plain, stretching from the foot hills of Himalayas in the north down to the deltaic stretch, has great physiographic variability with an intense network of 22 rival basins.

The vast alluvial plains of the State spread from Jalpaiguri and Siliguri in the north to the Sundarban creeks and the Kanthi littoral in the south. Broad physiographic divisions of this flood plain are the following :

1. The Northern Plains *(Terai Teesta Flood Plain)*

The northern districts have their turbulent rivers, which in rainy season are fast and furious and bring down heavy quantities of boulder, sand and silt which they deposit as quickly as they wash them away. The proper alluvial plain of North Bengal is found between 66m and 27m contour. The northern Flood plain can be subdivided into the following :

a. Piedmont Plains

This narrow width region is washed by 5 major rivers namely Raidak, Torsa, Tista, Jaldhaka and Mahananda with their numerous tributaries. Due to sudden fall in gradient, the rivers channels flare out and deposit the transported materials in the form of fans at the foothills.

b. Dilluvial Plains

Next to this Piedmont plain, Dilluvial Plains is formed by materials eroded from the Piedmont Fans as well as from the Mountains, this zone is inherently flood prone. The river channels are yet to establish themselves as meander loops and are often cut off when the magnitude of floods become exceptionally large.

c. Northern Reiverine plains :

South of the Dilluvial Plains extends the true riverine plains. This zone is divisible into two parts according to the disposition of the paleo-deltaic formations. In the east, within the southern parts of Jalpaiguri and Kochbehar, as the Teesta had changed its course eastward, it cause flooding and deposition of fresh alluvial materials with high sand content. In the western part, restructuring of the delta has not happened since the Mahananda and the Mechi have not changed their course. The entire zone is extensively cultivated for rice and jute.

d. Barhind Upland : (Part of Bindhyan Old Flood Plain as per Agro-climatic Classification)

This zone, formed of older ferralitic soils, covers a small area in the eastern part of Malda and South Dinajpur, known as Barind. The meander belt of Ganga, which extends for about 10 kms from both the bank lines is covered with most recently deposited silt.

e. Tal Lowlands (Part of Bindhyan Old Flood Plain as per Agro-climatic Classification):

Practically the whole of the South Dinajpur and the western part of Malda district covered by this zone that remains water logged for a considerable part of the year due to run off from Mahananda. During the monsoon season, these water bodies expand in size. Depending mainly on the monsoon rains, the Tal lowland is used for cultivation of rice in the depressions and jute on the relatively higher ground.

2. South Bengal Plains (Gangetic Flood Plain)

a. South Western plains :

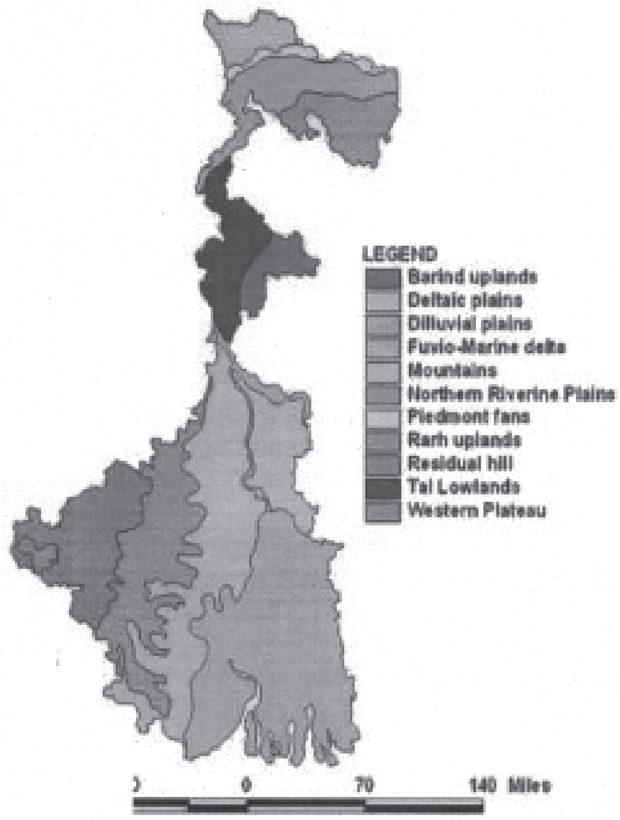
Known popularly as Rarh Bengal (Sanskrit word *roor* meaning rough and uneven) this region lies to the west of Bhagirathi and is a combination of ridge or hill, dome shaped residual mounds and extensive fluvial plains. In this region, the rivers like Mayurakshi, Brahmani, Dwarka, Ajoy, Damodar, Bakreswar Kopai, Silai and Kansai have curved wide valleys.

b. The South-Eastern plain

The area lying between Bhagirathi-Hugli in the west, Ganga-Padma in the north, Indo-Bangladesh border in the east and Bay of Bengal in the south is popularly known as deltaic West Bengal.

Demography

As is apparent from the table below, nearly half of the State's population inhabit the flood plains vast majority of which is employed in the agricultural sector. Gangetic flood plain, including the South Eastern and South Western flood plains mentioned above, has the highest density of population followed by Terai Teesta flood plain and the Old Vindhyan flood plains.



Flood Plains	Blocks	Area Sq.km	2001 Population	Density per sq km	2001 Cultivators
Terai-Tista flood plains	34	11337.98	7110651	627	792139
Old Vindyans flood plain	99	21294.82	17709310	832	1669995
Gangetic flood plain excluding deltaic region	92	15766.46	24257581	1539	1270420
Total	**225**	**48339.26**	**4090,77542**		**3732554**

Table 4.1 : Demography of the Flood plain regions of West Bengal *(Modified after Census, 2001)*

3.6 Changing weather and climate

For the state of West Bengal the maximum temperatures have risen by 1°C[1]. Average temperatures in Eastern India have risen by about 0.6°C over the last hundred years, in contrast to the average rise of about 1°C for the Indian Sub-continent as a whole.

Rainfall for West Bengal as a whole has registered an increase. But this increase is not uniformly distributed. In the monsoon months, the trend is towards decrease in rainfall in the months of June, a relatively mild increase in the months of July and August and a relatively greater increase in the month fo September. Outside the monsoon season, the winter months have registered a significant decrease in precipitation, while the pre-monsoon and post-monsoon seasons have registered a non-significant decrease and increase respectively. Much of these increases currently appear quite small; the September increase is about 2.8%.

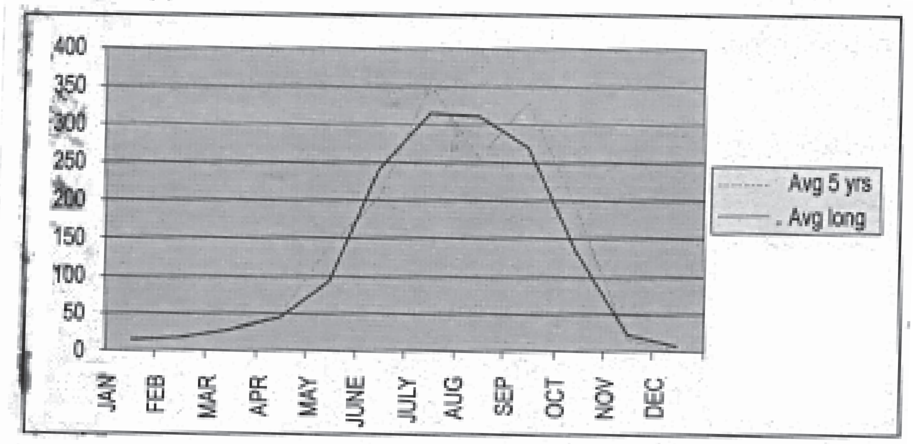


Figure 4.7 : (Year 1995-2000) 5 years' average Precipitation in Gangetic Flood Plain compared with long term trend : (2005-10)

Floods and Flood Proneness

One of the foremost issues in the climate change impacts on West Bengal is that of floods. The state appears highly vulnerable to the effects of high flows and impairment of the natural drainage mechanism of its rivers due to climate changes and extreme weather events inside and outside the State boundary.

West Bengal is one of the most flood-prone states in India with 37,660 sq. km flood prone area spread over 111Community Development Blocks. More than 43% of its total

1. This data is from Dash et al., Some evidence of climate change in twentieth-century India, Climatic Change, Vol. 85, p. 299, 2007.

geographical area at risk which is significantly higher than the all-India average of 12.17%.

Several of the particular features that lead to floods in both the Northern and Southern part of Bengal are likely to be exacerbated by the effects of global warming. The bulk of the flow in the Northern part is from the snowmelt fed rivers in the Ganga-Brahmaputra basin. The flow in these rivers abruptly decelerates on reaching the plains leading to heavy siltation and consequent rise of the river bed. In the short and medium term rising temperatures are likely to lead to greater flow from snowmelt due to higher summer temperatures while in the long-term flows could actually diminish with eventual glacier retreat. Sudden surges in volumes can occur due to both extreme rainfall events that are likely in this region where total rainfall is set to increase. Sudden surges can also arise from the floods due to glacial lake outbursts which can cause substantial damage downstream. Such flows may also occur due to the collapse of lakes created by landslides and slope failures.

Between 1960 and 2000 the State has had only five flood-free years, when less than five hundred square kilometres were inundated (Table 4.2).

Flood affected area (in sq. km)	**Years during which the flood occurred**	**Total No. of years**
Below 500	1985, 89, 92, 94 & 97	5
Between 500 2000	1962, 63, 64, 65, 66, 72, 75 & 96	8
2000 5000	1960, 61, 67, 69, 70, 74, 76, 80, 81 & 82	10
5000 10000	1973, 77, 93, 95 & 98	5
10000 15000	1968, 79, 83, 90 & 99	5
15000 20000	1971, 86, 87 & 88	4
Above 20000	1978, 84, 91 & 2000	4

Table 4.2 : Flood years between 1960 2000.

The floods in the Northern part are generally early in the season and tend to be intense and of short duration. The floods in the Southern part of the state are later in the season. The flood pattern in the Southern part is likely to be altered by both increased rainfall in the river basin areas and the slow rise of sea-levels. The outflow of these rivers being dependent on tidal conditions the effects of sea-level rise on the tides is a critical parameter in assessing the potential for floods in the southern part. As is by now well-understood, areas such as the Sunderbans which are in the deltaic region of the Ganga-Padma river system would be particularly vulnerable to flooding and the attendant consequences.

The following table illustrates incidence of flood post year 2000.

YEAR	Description of damage and casualities of affected areas
2001	Rains caused flooding in Kolkata and 68 adjoining municipalities affecting 18 million residents. UNICEF reported 1,886,976 houses, 2,375,636 hectares of cropland, 8,187 primary schools. 1.345 health facilities, 3,240 kilometers of highways and district roads, and over 450 kilometers of railway either damaged or destroyed.
2002	Flooding in Jalpaiguri, Cooch Behar and Jalpaiguri in north Bengal due to monsoonal rains. Flash floods swamped ten villages, causing 15 deaths and 11,000 displacements, 9,00,000 people were affected, 14 crore value of property damaged.
2003	Monsoonal rains caused floods affecting the regions of Darjeeling, Jalpaiguri, Malda and Murshidabad. In just two districts, e.g. Malda and Murshidabad as many as 85 villages of 25 GP's of 6 Blocks were affected.
2004	Heavy monsoonal rains affected several districts. Almost 1.7 million people were affected by the flood. One hundred and eighty thousand people were affected.
2005	About 3000 coastal villages were inundated and 60,000 huts and many roads washed away. The East and West Midnapore districts were the worst hit. There is also serious flooding in north and south Parganas. Howrah and Hoogly. In East Midnapore alone 2,500 villages were submerged followed by around 2,000 villages in West Midnapore
2006	16 out of 19 districts in the state were flooded. Most seriously affected district were Murshidabad, Nadia, Burdwan, Birbhum, Howrah and Hoogly. Over 8.3 million people were affected and near half a million houses were damaged.
2007	The hazard affected Kolkata and several other districts. Eighty-three deaths were reported, and millions of people were marooned in 3000 villages in coastal areas of the state. Three districts of West Bengal severely affected by floods with West Midnapore being the worst hit. On another incident, heavy rain from tropical depression in the Bay of Bengal caused flooding leading to 51 deaths, and affecting 3.2 million people.
2008	2.7 million people affected. In East Midnapore and West Midnapore district.

Table 4.3 : Incidence of flood after year 2000.

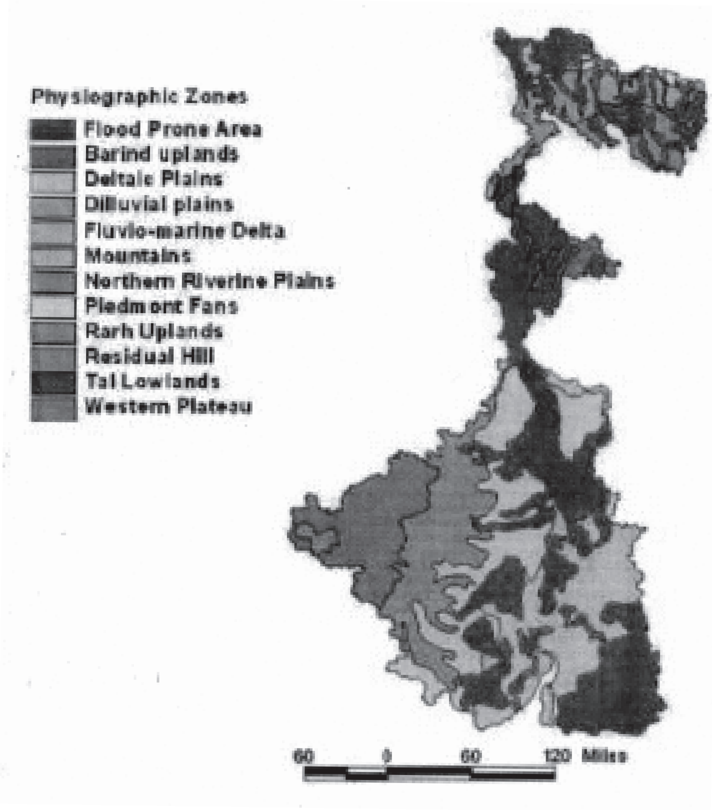


Figure 4.8 : Flood prone areas of West Bengal overlayed on the Physiographic zones.

Apart from floods, the erosion of river banks is also a particular cause for concern. Hot spots in this regard include the left bank of the Ganga upstream from the Farakka Barrage, and in other parts of the Ganga-Padma and Bhagirathi-Hooghly river systems. Several towns on the banks are threatened with annihilation in future if bank erosion continues unchecked.

Vulnerability of Agriculture

As shown earlier, agriculture remains the primary occupation of the vast majority of the population in the flood plains.

Khariff crop in general is at risk in the flood plain regions. This has serious implications for food security for a vast rural population under conditions of climate change.

Aman rice (Monsoon Paddy), one of the major crops in the State, is particularly vulnerable to flooding. The map below shows that majority of the *Aman* rice growing areas lies in the flood plain regions of the state. The same areas incidentally also have the largest concentration of cultivators.

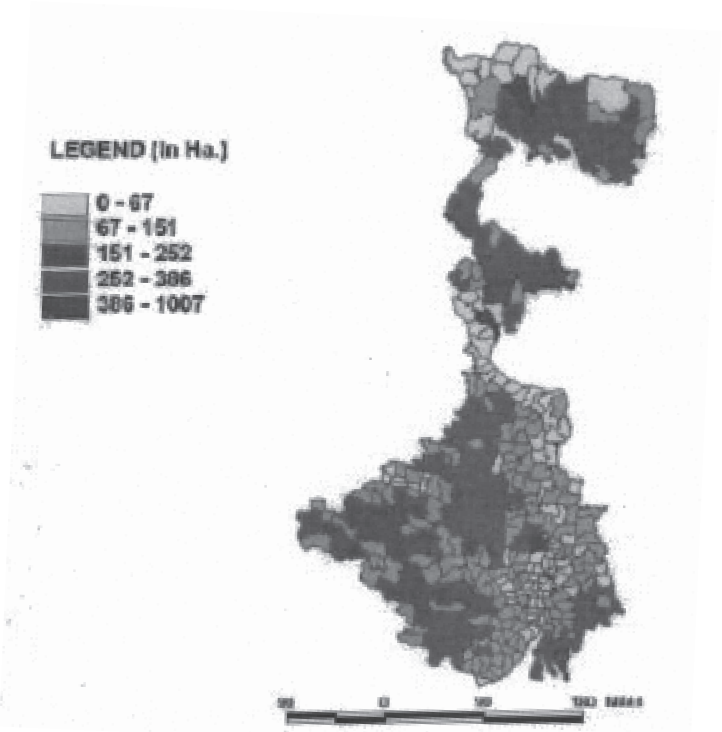


Figure 4.9 : Area under Aman Rice.

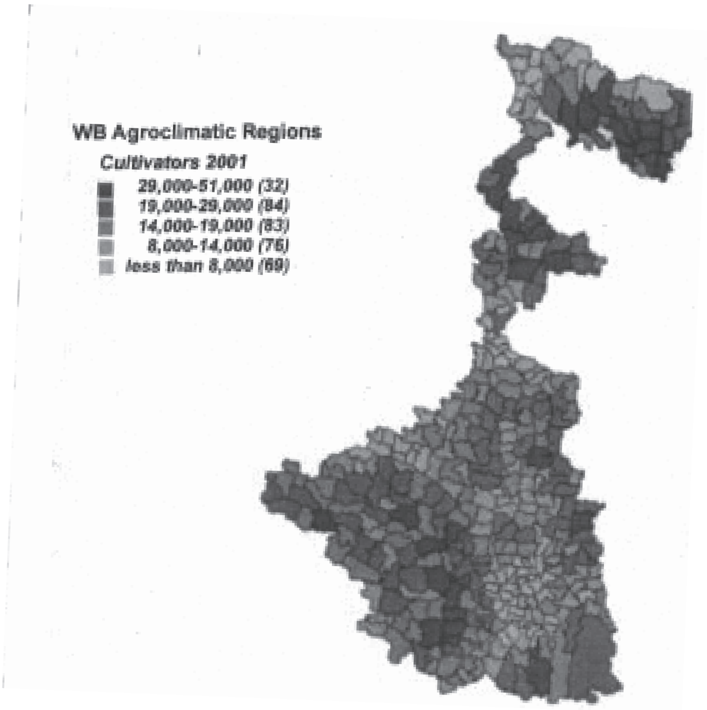


Figure 4.10 : Population of cultivators

Most studies that have considered the impact of climate change on crop performances indicate that *Rabi* (winter) crops would suffer most from temperature increases. Wheat and potato are two major winter crops for West Bengal.

Potato is a major cash crop in West Bengal, and contributes almost 30% of the country's production. Most of this production has been restricted to a few districts although the area under potato in other districts is also on the rise. The following maps (Fig. 4.8, 4.9 & 4.10) show that three districts, namely Hooghly, parts of Bardhaman and East Medinipur in the South Eastern flood plain have the largest area under potato cultivation in the state. Jalpaiguri district in the Terai-Teesta zone also has some potato cultivation. Similar considerations are true for the winter wheat crop too. Wheat, not a traditional crop in West Bengal, had picked up over last three decades. It is cultivated across 3,63,200 ha, mostly in Murshidabad, Malda, Nadia, Uttar Dinajpur, Jalpaiguri, Kochbihar and West Midnapore districts.

Apart from the vulnerability of these crops to rising winter minimum temperature, areas under these crops also lie in the flood prone areas and are hence vulnerable to flooding also.

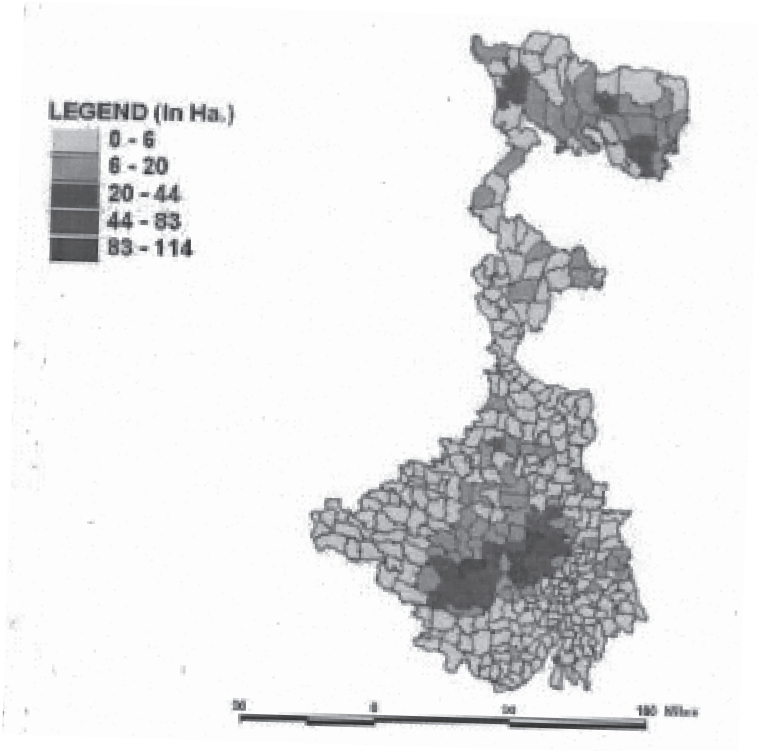


Figure 4.11 : Areas under Potato Crops.

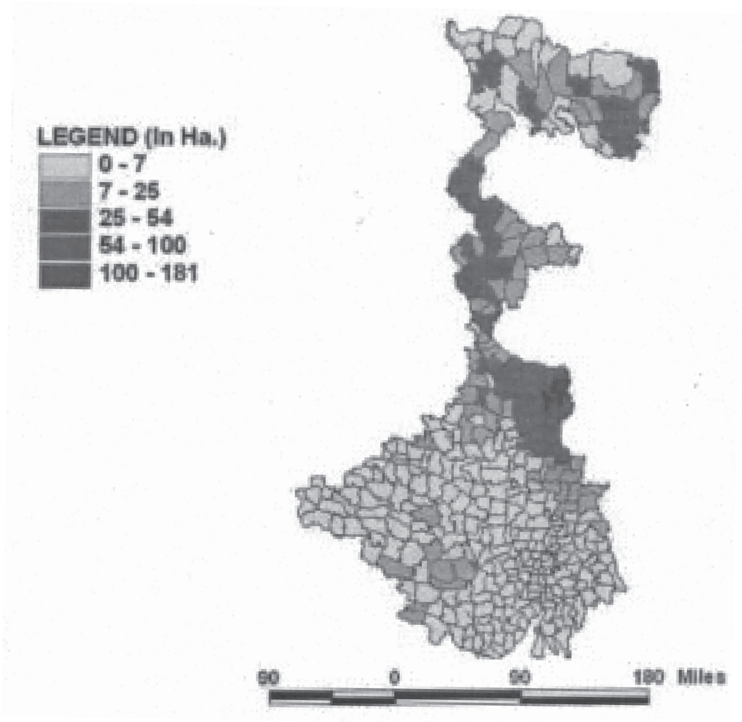


Figure 4.12 : Area under Wheat

Irrigation is a necessary part of reducing vulnerability not in the kharif season but in the rabi season. The decreasing trend of winter rainfall contributes to increasing vulnerability in the absence of expansion of irrigation.

3.7 Fisheries and Climate Vulnerability

West Bengal also has a special status in the production of fish seeds for inland fisheries. 75 per cent of the total demand for fish seeds for inland fisheries in India is met by West Bengal alone. Climate change impacts on fisheries are therefore an important area of study both from the regional and the national perspective. Breeding in hatcheries were based on techniques centered on the maturity period occuring until recently in the months of June-August. However it has been observed that the maturity and spawning now occur as early as March in the fish hatcheries of West Bengal and Orissa. The study attributes this to the rise in temperature between 0.37-0.67 °C in this region and changing patterns of precipitation. Currently the level of production shows that the fisheries industry appears to have adapted to this impact without any significant negative implications for fish production. However the increasing heat stress likely in the peak summer months may undo the adaptation that has occurred so far.

Housing

A significant source of vulnerability is the presence of a large stock of low-quality housing that is particularly prone to damage under conditions of increasing precipitation (and extreme rainfall events) or floods.

The growth in number of permanent houses (with both permanent roofs and walls) has been slow particularly in the rural areas of West Bengal. Between 1990 and 2000 the percentage of households with permanent houses increased from 17.69% in 1990 to 24.86% in 2000.

The growth of semi-permanent (with either permanent roof or wall) housing has been relatively better though still far from being satisfactory. Semi-permanent housing has grown in rural areas from 24.66% to 37.26% in the year 2000.

These figures indicate the need to urgently step up the growth of permanent housing now or in the near future as part of climate change adaptation, keeping in mind that more perceptible climate change effects may be due within a time span of two to three decades. Of course it may be added that the provision of permanent housing must be considered of the minimum requirements of reaching adequate levels of equitable development.

Drinking Water

Drinking water availability is of a major concern in the wake of climate change. Availability of safe drinking water is a critical issue in post flood scenario as well. West Bengal is a State that has moved over the years from the status of a water-surplus state to one that is increasingly water stressed in leaner months, though access to safe drinking water is higher than the all-India average. However drinking water availability is both temporally and spatially uneven. Per capita water availability has been steadily decreasing as shown in the table below.

Year	Population	Per capital water
1951	2.63	2574
1961	3.49	1940
1971	4.43	1528
1981	5.46	1240
1991	6.80	996
2001	8.02	844
2011	9.40	720

Table 4.4 : Availability of Drinking Water facility.

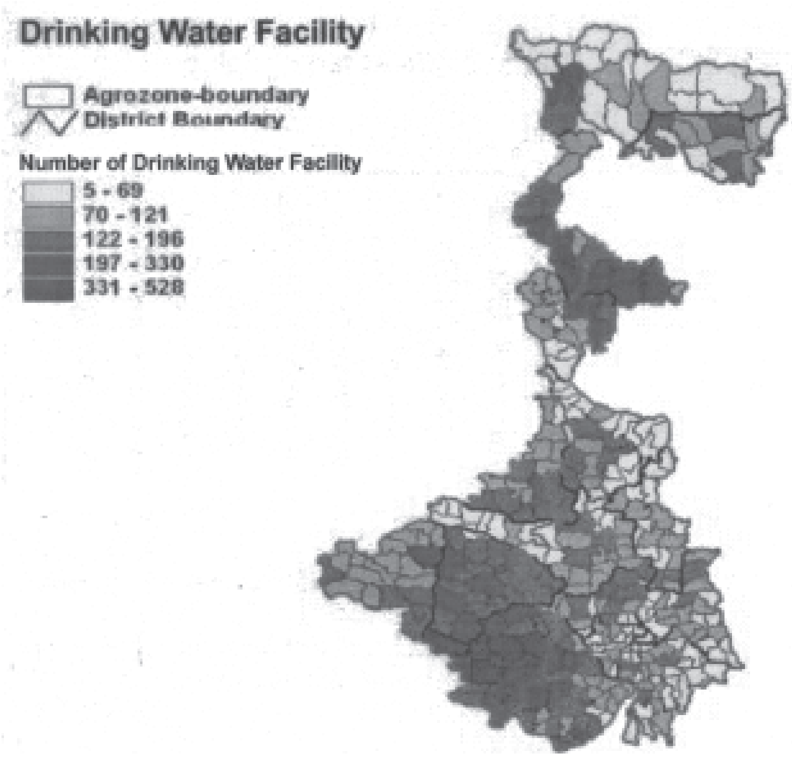


Figure 4.13 : Spatial variability of Drinking water facility.

Public Health

The following figure would illustrate the uneven distribution of public health facilities across various flood prone districts.

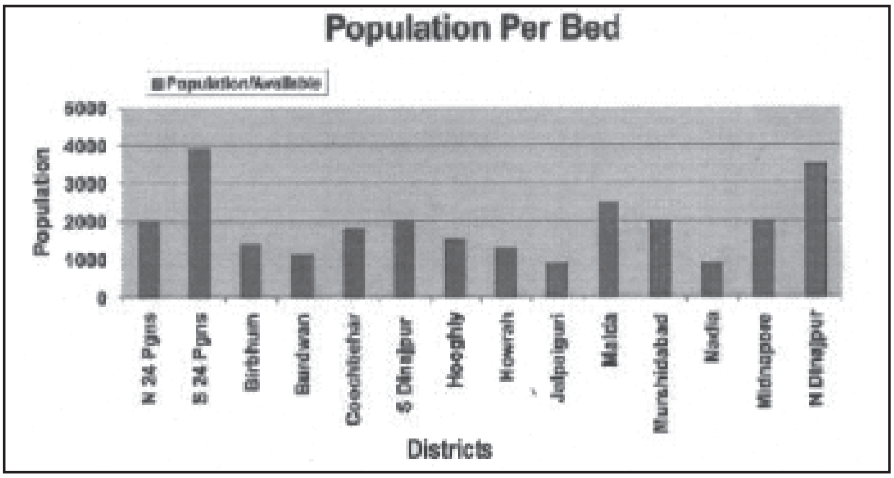


Figure 4.14 : Population catered by a bed in a health facility across flood plain districts.

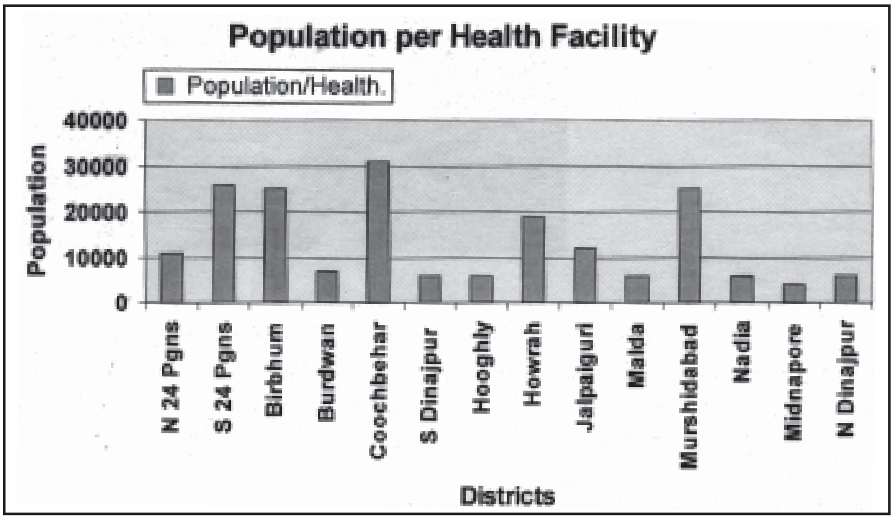


Figure 4.15 : Population catered by a health facility across flood plain districts

As is apparent from the figures above, pressure on either a health facility or an available hospital bed is high in a number of districts.

3.8 Suggested strategy for Adaptation

Flood preparedness and management

- Any interception across moribund channels in the flood prone areas requires to be removed and selective dredging needs be done to resuscitate them. The wetlands are natural reservoirs of water and all precautionary measures are to be adopted for conservation of such wetlands.
- Dissemination of data and access of vulnerable populations to disaster information system at the Panchayat Samity level. Early warning mechanism does exist in the state but serious gaps often exist between the information source and the vulnerable population.
- The State has a Disaster Manual, and is one of the very few States in the country that has it. But it is essentially meant for administrative operations. Family level and community level preparedness are still to be achieved. Family level preparedness means the measures by which, the family stocks food, fuel and fodder, prepares shelter *(Machhan),* fabricates a portable *chulla,* raises community tubewells for drinking water, uses bleaching powder and alum to make clean drinking water and many others depending on local need. Awareness building through suitable application of mass media is required.
- Community's preparedness refers to creation of community volunteer task forces

(on warning, search and rescue, water-sanitation, shelter management, carcass disposal etc.) training them on their job as well as pre-positioning of stocks (ORS, medicine, dry food) and boats to carry the affected in case it is necessary. Further a mock drill is conducted every year to remind people of Dos and Don'ts. Excellent field level examples are already available on community preparedness in several districts.

- Convergence of rural development schemes, particularly NREGA in post flood situation has to be achieved. Local civil society organizations may be identified who can facilitate such convergence process.

Agriculture & Fisheries

- A key issue in the State of West Bengal, particularly in the flood plain region, is the question of reducing dependence on agriculture (especially rain-fed agriculture) without endangering food security.
- At the next level, farmers who cultivate the same crop in more than one season would be vulnerable relative to those who grew a more diversified set of crops. The long-standing argument that a diversified cropping pattern makes for more sustainable agriculture, appears to have a renewed relevance in the context of climate change.
- There is urgent need of agronomic adaptations in relation to rain fall distributional changes as well as flood for *Aman* rice cultivation. Suitable introduction of indigenous varieties that are inherently adapted to changing climatic conditions and water logged situations has to achieved on an urgent basis.
- Adaptive measures are immediately required for winter crops, particularly- potato and wheat. Diversified cropping system at the farm level appears to be answer to tackle the climate vagaries related crop uncertainties.
- Integration of different subsystems like livestock, poultry, fishery, seasonal crop, perennial trees etc in the production system will reduce disaster risk, increase resilience and reduce dependency on a single livelihood. This can be done through reshaping land to drain out logged water and initiating fisheries there. Doing trellis and chicken shed over the pond, introducing biodigester to manage farm waste etc.
- As per the available information, inland aquaculture has been able to adapt to unchanged rainfall distribution pattern. Riverine fisheries may be significantly impacted by changes in flow patterns, flooding, etc. Flooding is critical to river species breeding in the months of June to August. Decreased precipitation in the middle region of the Ganges appears to have led to failure in breeding and a consequent decline in the availability of fish spawn. This has led to an overall decline of the major carps in the Ganges. This may have implications for river fish catches in Bengal. Alternative or supplementary employment generation seems to be the answer for the vulnerable fishing population.

Housing and Disaster shelter

As discussed above, majority of rural houses in West Bengal are still *Kuchha* or semipermanent. Although there is no scope of any dramatic intervention in this sector, scenario can be improved through effective and transparent implementation of existing rural housing schemes.

Construction of disaster shelter has to be taken up in the flood prone areas in particular for which there is still a sizeable gap.

Public Health & Drinking water

As discussed above public health delivery system is certainly not even across districts. More critical issue however is the quality of health management in a disaster scenario. Disaster medicine has emerged as a key discipline by itself. The medical and para-medical community need to be sensitized and equipped with current disaster medicine knowledge. Provision of safe drinking water is another critical area that needs immediate intervention. Mass awareness program on simple technologies like SODIS (solar water disinfection) taken up for water purification in the flood affected areas at the household level. Rain water harvesting and purification seems an answer too.

Regional Policy Action Platform on Climate Change (RPAPCC)

Climate change can be viewed as one of the most critical environmental problems to confront us as it is most immediately and inextricably linked to wellbeing, development and economic growth. Thus the solutions to it cannot be left to the confines of the environment but needs to seek clarity and consolidate its response relating the agendas and interests of the multiple constituencies.

Recognising the need for a coordinated proactive response to climate change, WWF-lndia has developed the concept of "Talking Solutions", which is a process that builds a consolidated understanding, informing a strategic response from among the various key constituencies.

Unit 4 ❐ Cyclone Risk Management

Structure

4.1 Killer Cyclones & Supercyclones

Killer Cyclones/typhoons/hurricanes/supercyclones may consume human lives to a great extent. It is noted that the more developed the countries, the lesser casualties would take place but greater economic losses are likely to occur. On the other hand, in poor countries, the human losses would be more but economic losses would be less. This is because the unit costs of damage assessed are lower. In the middle income countries, the damage to life and property would be somewhere in between. The poor countries can however make a big difference if the govts. invest to mitigate the effects of cyclones etc. in a cost effective manner.

Framework for preparedness and mitigation :

The most complex task of cyclone mitigation to be carried out initially is to map the hazard, risks and vulnerabilities of cyclone at all levels from the historical data with some changes as they happen today. The data should be analyzed to assess the levels of risks with the aid of GIS and monitor it continuously. On the basis of such an information, a proper and effective strategy for cyclone risk mitigation and preparedness can be developed. In fact hazard mapping involves time series data. It can show the zones, which are prone to the cyclones.

The ideal tool for assessment of cyclone risks and vulnerability at the local level should be a combination of scientific and traditional knowledge.

Acceptable risk & total risk

Require correct estimation of total and acceptable risk.

Total risk = all probable harmful consequences or expected losses from a disaster – deaths + injuries + damages to movable or immovable property + livelihoods +

infrastructure + disruption of economic activities + environment damage. Based on correct risk assessment (prediction or analyses of records) of disasters, it is possible to construct different scenarios of total risk according to location, intensity or time of disasters. This helps to take strategic decisions on how much can be mitigated and to what extent by various agencies.

The residual risk that can neither be prevented nor mitigated in a cost effective manner in the given circumstances can be regarded as acceptable risk. It will thus vary from place to place. Communities must be prepared to face these risks so that damage to life, property and livelihood from these risks can be reduced to their minimum. Ideally, the level of preparedness should be equal to the level of acceptable risk.

4.2 Mitigation :

A. 1. Structural – physical constructions or other developmental works to reduce the impact
   2. Non-structure – Education, training, capacity building, policies etc.

B. Investments in seawall construction and embankments reinforcing

C. Bioshields :
   Consist of mangroves, casuarinas, salicornia, laucaena, atriplex, palms, bamboo halophytes and other shrubs which inhabit lower tidal zones. Systemic regeneration required. Human habitation should be removed from mangrove forest in deltaic areas.

D. Cyclone shelters
   Investment in construction

E. Cyclone resistant housing and infrastructure
   — need properly trained engineers and masons
   — Need revised designs of buildings/houses
   — Old buildings need to be appropriately retrofitted

Early Warning and Communication :

Early warning of cyclones and its dissemination specially to the coastal habitations.

Community based disaster preparedness

Since official and outside response take 12 hours to 48 hours minimum, local communities must be mobilized and trained to assess their own risk, develop their own contingency plan and set up their own teams for evacuation, search and rescue and emergency shelter and first aid. Thus the risks of cyclones can be managed with significant reduction in casualties.

Risk transfer and risk financing :

Mounting economic losses due to cyclones cannot be compensated by the govt. Govt. support is limited to ex-gratia relief, support for the reconstruction of houses and livelihood generation for the poor. It also provides finance for reconstruction of the damaged public assets.

In the developed world, nearly 90% of the assets are covered by insurance against natural disasters. It has encouraged collateral involvement in disaster resistant housing and infrastructure. It tends to reduce the insurance premium. It facilitated transfer of the risks of the private sector and individual sector to the insurance companies. The insurance companies thus generate more business and the govt. reduces its expenditure on relief and reconstruction. At the same time the govt. encourages private investments in safer buildings and safer and better infrastructure. This needs to be adapted in the developing world like India. Moreover microcredit, a microfinance service may increase the resilience of local communities. Microcredit is specially playing an important role in trying to combat the vulnerabilities of the poorer sections of the community in developing countries.

4.3 Capacity development and training

Local capacities development, the most effective method of reducing vulnerability of the people needs to be monitored and continuously modified with new inputs. It will be in response to the changing needs. Capacity development can be through meetings, instructions, discussions, exposure visits and training. Training includes maroon search, rescue, first aid, evacuation, temporary shelter management, arrangement of drinking water and sanitation, provision of cooked food etc.

4.3.1 Awareness and Education

Cyclone education programme should be introduced in the school and college curriculum. Through interactions, the communities may be sensitized. Electronic, print and folk media can play roles in awareness generation on a large scale.

Awareness and sensitization programmes can also be organized for more specific and limited audience like Panchayat members, MLAs, MPs, policy maker, media and other selected groups.

Contingency Plans

Cyclone risk management as a mitigation effort must have a contingency plan in readiness. It would clearly delineate the roles and responsibilities of various agencies within and outside the govt. The plan should define the exact functions to be performed by different agencies, the process to be followed in the performance of the functions. Moreover the tools and equipment proposed for the process should be kept ready.

Evacuation drills must be followed and emergency medical plan put in the place. Standard operation procedure should be laid down for each activity of the agencies involved. The plan should be updated from time to time. Proper co-ordination between the working groups must be ensured. Otherwise there will be chaos. Conducting mock drills 4 times a year is the best way to be effective with the plan. It ensures operational readiness of the total system. In addition, to bring normalcy back after the disaster, the administration and community, used to cyclone, should have a ready pre-disaster recovery plan.

Table 4.5 — Cyclones that killed more than 1000 persons since 1950

Basin	Cyclone	Year	Countries	Deaths
North Indian Ocean	Cyclone	1963	East Pakistan	22,000
	Cyclone	1965	East Pakistan	17,000
	Cyclone	1965	East Pakistan	30,000
	Cyclone	1965	Karachi, Pakistan	10,000
	Cyclone Bhola	1970	East Pakistan	300,000
	Cyclone	1985	Bangladesh	10,000
	Cyclone Gorky	1991	Bangladesh	131,000
	Cyclone	1971	Orissa, India	10,000
	Cyclone	1977	Andhra, India	20,000
	Cyclone	1996	Andhra, India	1,000
	Cyclone	1998	Gujarat, India	1,000
	Cyclone	1999	Orissa, India	9,500
West Atlantic	Hurricane Flora	1963	Cuba, Haiti	8,000
	Hurricane Inez	1966	Caribbean, Mexico	2,000
	Hurricane Fifi	1974	Central America	5,000
	Hurricane David	1969	Central America	2,608
	Hurricane Mitch	1998	Central America	11,000
	Hurricane Katrina	2005	New Orleans, USA	1,836
East and South Pacific	Typhoon Iris	1955	Fujian, China	2,334
	Typhoon Sarah	1959	Japan, South Korea	2,000
	Typhoon Vera	1959	Japan	4,466
	Baguious Thelma	1991	Philippines	3,000

Since 1950, about 602,908 people died due to the above killer cyclones. Most of the deaths could have been prevented if basic and elementary measures and preparedness were in place. The relation between intensity and damage of the cyclones shows that there is a correlation between the level of economic and social development of the countries most affected and the state of preparedness of the communities. Till date, the deadliest of all was the cyclone Bhola of 1970 in the erstwhile E. Pakistan classified as Category III — (max. windspeed 205 km lowest pressure 966 hPa and storm surge 4 m^3) but it killed 300,000 people while the economic loss was estimated at only US$86.4 million. In contrast, hurricane Katrina of August 2005 in New Orleans was classified as Category IV (maximum wind speed 280 km, lowest pressure 902 hPa and storm surge 6 m)[3] but the casualties, despite the terrible mismanagement of the crisis, was limited to 1836, while the economic loss mounted to US$81.2 billion. Hurricane Mitch of 1998 in Central America, on the contrary, was classified Category V (maximum wind speed 285 km, lowest pressure 905 hPa and storm surge 8 m^4) killed 11,000 people and damaged assets worth US$4 billion.

It is clear from these three catastrophic cyclones in three representative poor, rich and middle-income countries that the more developed the countries, the lesser casualties would take place but greater economic losses are likely to be sustained. Conversely, in poor countries the human losses would be more but economic losses would be less simply because the unit costs of damage assessed are lower. In the middle-income countries, the damage to life and property would be somewhere in between. The poor countries can, however, make a big difference if the governments invest to mitigate the eff-ects of cyclones in a cost-effective manner and the communities prepare to face the cyclones in a participatory and sustainable manner.

4.3.2 Preparedness and Mitigation

Figure 4.16 shows the framework for cyclone risk mitigation and preparedness. Each component is discussed in detail below.

Risk analysis

The first and probably the most complex task of cyclone mitigation is to map the hazard, risks and vulnerabilities of cyclone at all levels, analyze and assess the levels of risks and monitor it continuously. It is only on the basis of such a knowledge base that a proper and effective strategy for cyclone risk mitiga-tion and preparedness can be developed.

Atmospheric studies and remote sensing have helped immensely in the understanding of the phenomenon of cyclones. Satellite images can spot the development of low-pressure zones; Doppler radars can track them down and instrumented aircrafts can reach the cyclone eye, eye walls and spiral bands to transmit data on wind velocity, pressure and moisture content. Powerful software tools are available to analyze the data to make fairly accurate forecasts on the intensity, direction and location of the landfall and the likely areas to be affected by winds, rain and storm surges.

The time series data on cyclones have been utilized to map and zone the areas prone to the hazards of cyclone. Such maps are now available at a regional, district and even subdistrict levels in most of the countries. Such maps are also available in digital formats which enable integration of various spatial data with socioeconomic, housing, infrastructure and other variables that can provide a quick assessment of the risks and vulnerabilities of cyclones based on which appropriate mitigation and preparedness strategies can be developed. But actual work on such data integration has been limited to a few areas only and therefore, vulnerability analysis still needs ground-level data collection and analysis, which is yet a largely unattended task in most of the countries.

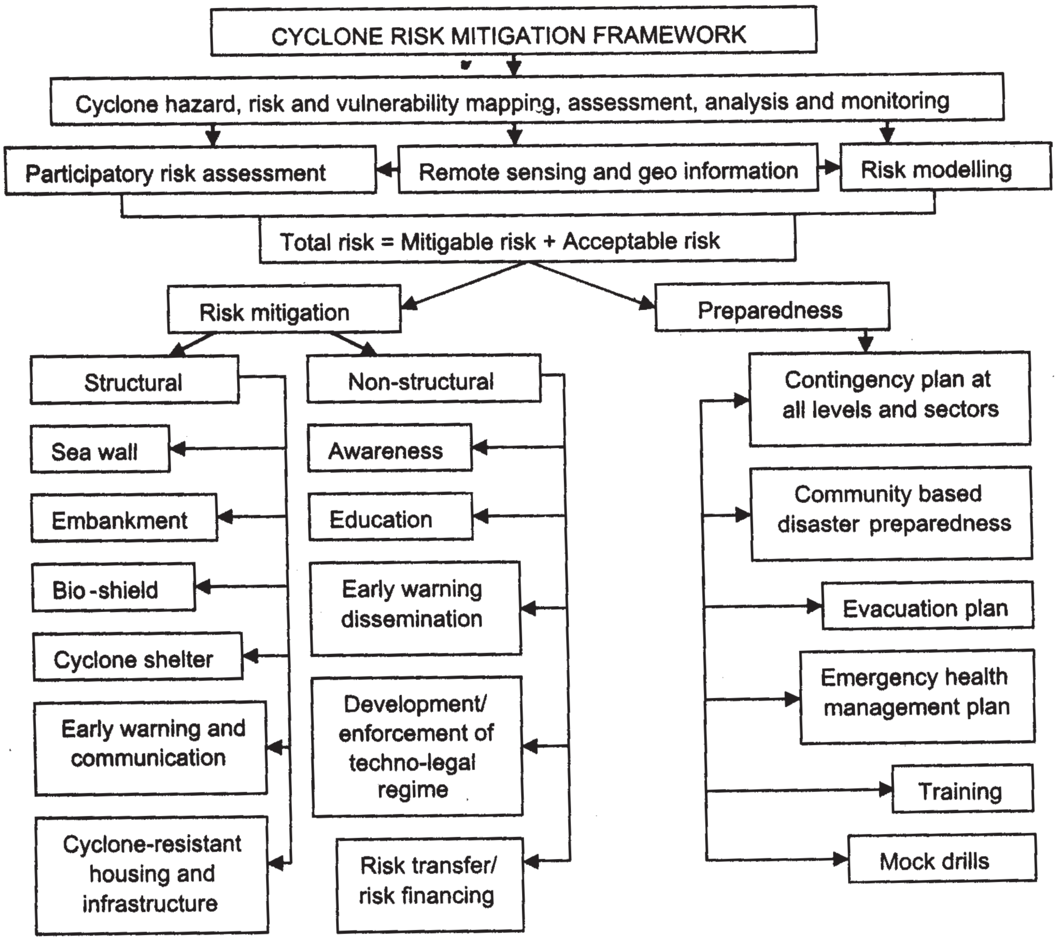


Fig.4.16—Cyclone risk mitigation framework.

The satellite imagery is also supplemented by data regarding topography, vegetation, hydrology, land use, land cover, settlement pattern and so on to help develop numerical models of storm surge and the inundation levels. Based on these models timely warnings "can be issued and realistic evacuation plans can be drawn up to shift the people and cattle likely to be affected by the cyclone. However, such theoretical advances on cyclone modelling have been confronted with constraints in practical applications which would require more sustained research for accurate forecasting and simpler application format that would enable transfer of the technology to the planners and emergency response managers. The constraints are further compounded by non-availability of accurate ground-level database and the costs involved in upscaling such models from a pilot research phase to countrywide application phase. Such attempts are still in progress even in advanced countries and therefore developing countries may not have the benefit of such accurate modelling in the very near future although this is well within the realm of possibility. The constraints discussed above highlight the relevance and importance of community-based Participatory Risk Assessment (PRA). Many such PRA tools have been developed in coastal areas which capture the intimate knowledge and perception that a community has about its own risks and vulnerabilities. Such perceptions have often been validated by scientific analysis, lending credence to the reliability, simplicity and cost effectiveness of such assessment. More importantly, it involves the communities in the entire process making it democratic, sustainable and proactive and definitely facilitates bridging the gap between assessment and preparedness or knowledge and action.

Historically, the coastal communities have faced the furies of Nature and have inherited an intuitive and holistic knowledge of the way it behaves and the impact on animals, plants and human lives and livelihood. Accordingly, communities have learnt to develop indigenous coping mechanisms for survival, which were internalized as lifestyle activities and transmitted from one generation to another. Many isolated communities in the coasts have survived through this process. Unfortunately, the process of so-called modernization and globalization are resulting in changes in the lifestyle of the coastal communities and much of the traditional wisdoms and practices is fast dying out. There is a need to document these practices, assess their relevance and adapt them according to the changing conditions.

Therefore, the ideal tool for assessment of cyclone risks and vulnerabilities at the local level should be a combination of scientific and traditional knowledge, each supplementing the other in a manner that science corrects those superstitions and dogmas of traditional knowledge that are not substantiated; while traditional knowledge enriches scientific truths with the time-tested' experiments and experience of centuries that cannot be simulated. Such ideal solutions are not very common, but the two complementary processes—increasing the spread of scientific education on the one hand and growing respect for traditional and indigenous knowledge on the other—are creating awareness of such solutions, highlighting need for increased collaboration among the physical and social scientists for cyclone risk assessment and analysis at the local level.

Total and acceptable risk

Any strategy for cyclone risk mitigation or for that matter mitigation of any disaster risk would depend on correct estimation of total and acceptable risks. The concept of 'total risk' connotes the sum total of all probable harmful consequences or expected losses from a disaster such as deaths, injuries, damages to movable or immovable property, livelihoods, infrastructure, disruption of economic activities or environment damage. It may not always be easy to project such damage because environmental or psychosocial damage would be difficult to quantify; but based on correct risk assessment of disasters, it should be possible to construct different scenarios of total risks according to the intensity, location or time of disasters. Once realistic assessment of total risks is available, the countries and communities should make strategic decisions on how much of these risks can be prevented outright, how much can be mitigated and to what extent by the various agencies.

The residual risks that can neither be prevented nor mitigated in a cost-effective manner in the given social, economic, political, cultural, technical or environmental conditions can be regarded as 'acceptable risks'. Therefore, the level of 'acceptable risk' would vary from place to place and also from time to time. Once the level of 'acceptable risk' is decided, countries and communities must be prepared to face these risks so that damage to life, livelihood and property from these risks can be reduced to their minimum. Ideally, the level of preparedness should be equal to the level of 'acceptable risk'. Excess preparedness in any sector or level would be wasteful which should better be avoided. Similarly, deficit in preparedness would be taking a chance with risks that may cause avoidable damage.

Types of Mitigation

Given the nature of the cyclonic hazards, it would not be possible to prevent the risks of cyclone however advanced the country may be socially or economically, as has been well demonstrated during the aftermath of hurricane Katrina in the USA. On the contrary, there are indications that the hazards of cyclone would increase due to the effects of global warming and the resultant climate changes. As the ocean surface temperature rises, the probability of atmospheric depressions on tropical seas would increase. Similarly, as the glacial melts raises the ocean level, the impact of storm surges would be more severe and many seawall or embankment modelling done in the past may undergo revisions necessitating redefinition of the design parameters of such constructions.

In the face of increasing risk of cyclonic hazards, mitigation would remain the key and the most effective strategy to reduce the risks of cyclone. Every country and community has to decide its own mitigation strategy according to its own risks, resources and capabilities. Broadly, such strategies would be two-fold: structural and non-structural. Structural mitigation measures generally refer to capital investment on physical constructions or other development works, which include engineering measures and construction of hazard-resistant and protective structures and other protective infrastructure. Non-structural measures refer to awareness and education, policies, techno-legal systems and practices, training, capacity development and so on.

Seawall and embankments: Among the structural mitigation measures, seawalls and saline water embankments are probably the most effective and capital-intensive invest-ment to mitigate the risks of cyclones. A seawall is constructed usually of reinforced concrete on the inland part of a coast to prevent the ingress of storm surges arising out of cyclones. Sometimes, the seawall is constructed with a multiple purpose of reclaiming lowlying land or preventing coastal erosion. The height of sea walls is determined according to the maximum observed height of storm surges which may be as high as 10 m. Therefore, seawalls are usually massive structures which can be built only with a heavy investment. Maintenance of such structures also requires recurrent expenditure. Hence, seawalls along the entire coast are never a practicable solu-tion to prevent or mitigate storm surges, but such walls are recommended when valuable assets like a city or a harbour need to be protected.

Seawalls can be vertical, sloping or curved. Modern concrete seawalls tend to be curved to deflect the wave energy back out to sea, reducing the force. There are instances of many seawalls which were constructed after devastating cyclones and which successfully prevented such disasters. The most important is the 12 km long and 17 ft high seawall constructed in Texas after the Galveston Hurricane of 1900 which killed 8000 people. The seawall has never been overtopped by a storm surge from a hurricane, although maintenance of the wall has been beset with various engineering problems. The Gold Coast seawall in Australia was laid along the urban sections of the Gold Coast coastline following 11 cyclones in 1967. The massive stone seawall in Puducherry constructed and maintained by the French engineers kept the historic city centre dry even though tsunami waves of December 2004 had driven water 24 above the normal high-tide mark. Similarly, 3.5 m-high seawall in Maldives saved the city of Male from the tsunami. Such success stories are available from many coastal cities. There are also instances where absence of such protective structures near the beaches and resorts and breaches in seawalls near the cities and towns resulted in severe damage to life and property.

If seawalls are essential to protect coastal cities and harbours, saline water embankments are recommended to protect rural settlements and to prevent saline water ingress into agricultural and horticultural land. Such embankments are usually a ridge built with earth or rock to contain the storm surges. Cost-benefit calculations usually do not permit very high specifications for such constructions and therefore, effectiveness of such embankments in preventing or mitigating the impacts of cyclones have been rather limited. Further, saline embankments have the potential to kill the mangroves due to chocking of saline water. Therefore, such embankments should be constructed in limited areas where vegetative protection would not be adequate to prevent the ingress of saline water into habitations.

Bioshields: Bioshields usually consist of mangroves, casuarinas, salicornia, laucaena, atriplex, palms, bamboo and other tree species and halophytes and other shrub species that inhabit lower tidal zones. These can block or buffer wave action with their stems, which can measure upto 30 m and several metres in circumference. They trap sediment in their roots, thereby maintain a shallow slope on the seabed that absorbs the energy of tidal surges. They also break the high velocity of winds and thus protect agricultural crops besides providing shelter and grazing lands for the livestock and farms. They reduce evaporation from the soil, transpiration from the plants and moderate extreme temperatures. They protect fertile coastal agricultural land from erosion. They also serve as carbon sinks as they help enhance carbon sequestration which makes coastal communities eligible for carbon credit to earn additional income. Besides, they promote sustainable fisheries by releasing nutrients into the water.

Unfortunately, the multiple and long-term environmental protection and economic functions of the bioshields have not been adequately appreciated until very recently. Unabated anthropogenic pressures of coastal settlements and unchecked commercial exploitation of coastal resources have resulted in denudation of such natural buffers exposing large areas to the vagaries of cyclonic storms. In the state of Orissa, where the lowlying coastline has been stripped of mangroves to make way for shrimp farms, the super cyclone of 1999 left more than 10,000 people dead and around 7.5 million homeless. Although the cyclone affected over 250 km of Orissa's coastline, it was only the highly denuded area of 100 km through which water surged. Other areas with intact mangrove forests were largely unaffected. Again the Indian Ocean tsunami of 2004 impacted those areas more severely where the bioshields buffer was either not available or depleted considerably. In such areas, tsunami waves made deep ingress into land, ruined crops, drowned livestock and poisoned arable land and water supplies with salt. Mangroves and other coastal habitats, where still in existence, met the tsunami head on. For instance, the Pichavaram mangrove forest, a tourist attraction in Cuddalore district, protected about 6,000 people living in six hamlets located between 100 m and one km from the mangroves. Seawater did not enter the village and hence there was no loss of property.

Therefore, systematic regeneration of the bioshields in the coastal belts, wherever feasible, is the most natural and cost-effective method of protecting these areas from storm surges and erosion. This is not an easy task that can be achieved instantly since there is a time cycle for such plantations to grow and survive against fresh pressures of winds and waves. Therefore, serious efforts are required in designing such bioshields, selecting the appropriate fast-growing species suitable for the agro climatic zones and involving the coastal communities in the maintenance and protection of such buffer zone of plantations.

Cyclone shelter: A large number of the poor people in the coastal areas live in thatched houses which cannot withstand the high wind velocity and storm surges and hence suffer extensive. The high rates of casualties in cyclones in Bangladesh and India ax primarily due to unsafe buildings in the coastal areas. The poor economic conditions of the people may not permit them to rebuild their houses as per the cyclone-resistant designs and specifications. Therefore, community cyclone shelters constructed at appropriate places within easy access of the vulnerable communities can provide an immediate protection from deaths and injuries due to the collapse of their houses. Such shelters are usually built on pillars above the danger level of storm surges/inundation, are spacious enough to accommodate a few hundred people of the neighbouring hamlets and provide provisions of drinking water, sanitation, kitchen and so on. During the normal season, such shelters can be utilized as schools, dispensaries or other community purposes.

A large number of such cyclone shelters were built in the coastal areas of Bangladesh and eastern and south India, which provided immediate shelters to the vulnerable communities. Drastic reduction in the number of deaths and injuries in the cyclones during the past five or six years can be partly attributed to these shelters. Therefore, the governments have placed a very high priority on the construction of such shelters in areas which have hitherto not been covered.

Cyclone-resistant housing and infrastructure: Supercyclones with wind velocity of 250 km/h and above have caused damage to even engineered structures at many places around the world. This was largely due to the absence of appropriate design criteria for construction of buildings and infrastructure which can withstand the pressures of such strong winds. Bureau of Standards of various countries have developed revised design norms which are followed for new constructions. However, the compliance standards of such norms have not been very effective largely due to inadequacies of properly trained engineers and masons who can supervise and raise such constructions. The problem is further compounded by a weak and ineffective system of enforcement of the guidelines.

The problem is even more complex for the large number of existing structures that have already been constructed without adherence to the revised norms. Such buildings can only be retrofitted with an additional cost which the homeowners find reluctant to invest. Many advanced countries have passed legislation which has made retrofitting mandatory. In the developing countries, the focus is confined more to strengthening the lifeline buildings which would play a critical role during emergency operations such as hospitals, emergency operation centres, police control rooms leaving other unsafe struc-tures and habitations as ‘acceptable risks’, for which adequate preparedness measures should be developed.

Early warning

Early warning of cyclones and its dissemination to the coastal habitations is an important preparatory measure to reduce the losses of life and property during cyclones. Due to heavy investments involved in the installation, operation and management of modern early warning system, it is also considered as an essential component of structural mitigation.

Rapid development of science and technology has brought in changes in the early warning and communication systems. Powerful Doppler radar systems can now track the movement of atmospheric depression and accurate early warnings can be issued 48-72 hours in advance about the probability of cyclone, its intensity and wind speed, direction and possible location of the landfall. Such warnings are broadcast through the radio and television network for the information of people in the coastal areas. Based on the data generated by the system, numerical modelling on storm surge and flooding can forecast the inundation level from where the affected population can be evacuated to safer places. There are hundreds of such instances where early warning helped to save thousands of lives in the coastal areas. However, inaccuracies in the modelling exercises have, sometimes, led to exaggerated responses leading to unnecessary evacuation of hundreds of persons which could have been avoided. Such inaccurate predictions sometimes reduce the faith of coastal communities on the early warning system, which need to be avoided at any cost. It is expected that with further advances of early warning technology, the predictions would be more and more accurate leading to better responses in emergency situations. It is also expected that increasing coverage of radio and television, more extensive use of ham radios and innovative use of mobile communication system would facilitate better dissemination of early warning to the isolated coastal communities particularly in the remote islands. The dissemination system can be made more effective with the active involvement of the communities and households in the preparation of their own cyclone contingency plans.

4.4 Disaster preparedness : An approach

Communities are the first real time responders to any disaster situation. However developed or efficient a response mechanism could be, there would always be a time gap between-the disaster and the actual response from the government and other agencies. In the case of Mumbai flood of July 2005, the response time was 12 hours while in the case of hurricane Katrina a month later it was more than 48 hours. During this critical period it is the community which has to look towards itself for self-help. Therefore, if the communities are mobilized and trained to assess their own risk through participatory risk assessment process, develop their own contingency plans' and set up their own teams for evacuation, search and rescue, emergency shelter and first aid the risks of cyclones can be managed with significant reduction in number of deaths and injuries.

The post-1991 cyclones in Bangladesh have demonstrated how a Community-based Disaster Preparedness (CBDP) programme could make a drastic reduction in the risks of cyclonic disasters. Therefore, more and more governments have adopted CBDP as an important strategy for disaster risk management particularly in the coastal areas. The Government of Philippines has, in fact, amended the laws to devolve certain emergency response functions to the communities. The Government of India is implementing the largest ever CBDP programme in 169 multihazard districts of 17 States covering nearly 300 million people.

Risk and what can be done about it

Mounting economic losses due to cyclones cannot be compensated by the government whose role would be limited to providing exgratia relief to the next of kin of persons who have died or those who sustained injuries and to provide support for the reconstruction of houses and livelihood regeneration for the poor and lower middle class people. Government support would also be necessary for reconstruction of the damaged public assets. The risks of industrial, commercial and other infrastructure and assets in the private and household sector can only be secured through the mechanism of risk financing and risk insurance. As the country develops, the share of private sector in the GDP would increase and, therefore, risk financing would assume increasing importance. In the developed countries, nearly 90% of the assets are covered by insurance against natural disasters which has encouraged collateral investment on disaster-resistant housing and infrastructure so as to reduce the premium for insurance. This has been a win-win situation for the private and individual sector in transferring their risks to the insurance companies, for the insurance companies in generating business and for the government in reducing its expenditure on relief and reconstruction while at the same time encouraging private investments for better safety standards for buildings and infrastructure. The experiences gained in this regard need to be further adapted according to the conditions of lower and middle income countries. Various innovative services and products like micro-insurance ?rJ microcredit, have been developed in many countries for increasing the resilience of local communities. Microcredit is particularly playing an importance role in retrofitting the vulnerabilities of the poorer sections of the community, especially the women, in the developing countries.

Capacity development and training

Capacity development is the most cost-effective method of reducing the vulnera-bilities of the people living in the coastal areas. The coastal communities have a certain degree of capacities built into their social systems and practices acquired through inherited experiences of generations. But such indigenous capacities are often overwhelmed by the vagaries of Nature due to various anthropogenic factors like the degradation of environment, changing land use, pressures of population on settlements and climate change. Therefore, the local capacities have to be continuously upgraded and further developed according to the changing needs and the developments in science and technology and other improved practices in various sectors, The challenge of capacity development is to transfer the new horizons of knowledge into actionable modules at the local levels for the local people by the local community. Such capacities can be developed through meetings, interactions, discussions, exposure visits and training.

Training is particularly necessary for cutting-edge functionaries within and outside the government at various levels in different sectors to impart them with necessary skill for cyclone risk reduction and management. Training programmes have to be practical, scenario-based and exercise and problem solving-oriented so that the functionaries are aware of their specific responsibilities and are able to discharge those responsibilities efficiently before, during and after the cyclonic disasters.

Training is also required for those community members who would be part of the community response teams for the initial critical hours and days till specialized assistance from the government and non-governmental agencies from the outside are organized. Such training may include maroon search and rescue, first aid, evacuation, temporary shelter management, arrangement of drinking water and sanitation, provision of cooked food and so on Such training can be better organized by a core group of community trainers who can be trained intensively by the specialized government and non-government agencies.

Education

While training and capacity development target specific groups according to their specific training needs, awareness generation is more general in nature and sensitizes common masses about the risks, vulnerabilities of cyclones and the preventive, mitigative and preparedness measures that can be taken at the government, community, household and individual level. Electronic, print and folk media can play important roles in awareness generation on a large scale.

Awareness and sensitization programms can also be organized for more specific and limited audience such as parliamentarians, policymakers, media and other selected groups.

Cyclone education programme, on the contrary, would be more formalized curriculum which can be institutionalized within the education system at various levels. Disaster management has already been included in the educational curriculum of the schools in many countries and cyclone risk mitigation can be a part of such curriculum. Various branches of science and technology can have course modules on Cyclone Risk Management. For example, civil engineering and architectural courses can have curriculum on cyclone-resistant housing and infrastructure. Medical and mental health sciences can have course module on emergency health and trauma management for cyclone-affected people, while IT and Communication sciences may have courses on Early Warning and Communication. Such curriculum at various levels of general and professional courses would help to develop necessary professional expertise to support the disaster risk mitigation and preparedness programmes of the government and other agencies at different levels.

4.4.1 Pre-Disaster Contingency Plan

In the not too distant past whenever a severe cyclone storm struck, the coastal areas in the developing countries, the communities and government have mostly been caught unawares and often they have been so overwhelmed by the all-round damage and destruction that it took quite some time for them to recover from the initial shocks and to plan and act in a coordinated manner, resulting in considerable chaos and confusion not only among the decisionmakers but also the emergency responders and other key stakeholders. Coordination among the agencies became a casualty in a crisis situation which greatedly affected the relief and reconstruction operations.

The disastrous consequences of an absence of a pre-disaster contingency plan has been demonstrated repeatedly in many countries on a number of occasions. Therefore, one of the most critical elements of cyclone risk management is to have a contingency plan in readiness, which would clearly delineate the roles and responsibilities of various agencies within and outside the government, define the exact functions to be performed by them, the process to be followed in the performance of these functions, the tools and equipments to be kept in readiness, procurements to be made, evacuation drills to be followed, and the emergency medical plan to be put in place. Such a contingency plan should be prepared vertically at the national, provincial, district and sub-district and community level and horizontally for the different sectors—police, civil defence, health, fire services, food and civil supplies, agriculture, fisheries, water supply, roads and bridges and so on.

Standard operating procedure should be laid down for each activity to avoid any confusion and to ensure coordination among the various agencies involved in the response, relief, rehabilitation and reconstruction programmes after the disasters. Such contingency plans should be reviewed periodically to update them according to changing situations and also to create awareness among all the stakeholders. The best way to keep the contingency plan in readiness is to conduct mock drills at least once a year before the cyclone season starts so that the operational difficulties in implementation of the plan can be sorted out at the ground level and the various agencies within and outside the government can work together in a coordinated and efficient manner when the disaster would actually strike. Such mock drills again should be conducted at various levels to ensure operational readiness of the system.

Even with all these mitigation and preparatory measures in place the cyclones would continue to strike the coastal settlements and probably these would strike with more frequencies and greater intensities in future. Death, injuries and losses can no doubt be reduced with better preparedness and mitigation measures, but these cannot be avoided altogether. The challenge would be how efficiently the damage is managed, how best the affected people are rescued and provided relief and rehabilitation assistance in a humane and transparent manner, how fast the damaged houses and infrastructure are reconstructed and how quickly the pre-disaster situation is restored and normal life bounces back to its rhythm. This would require pre-disaster recovery planning to be in place, ready for implementation, whenever a disaster strikes.

Unit 5 ❒ Tsunami Risk Reduction

Structure

5.1 Magnitude and Intensity of a Tsunami

A tsunami is a series of water waves generated by unusual abrupt and large disturbances of the sea-floor caused by earthquakes, volcanic eruptions, landslides, slumps and meteor falls.

The term tsunami is derived from 2 Japanese words – 'nami' meaning a wave and 'tsu' implies a harbour or port. Since the tsunami generated by an earthquake under the sea is small it could be significantly amplified to be noticed by the people in the shallow coast, esp. in a port and/or a harbour.

Since a large earthquake in a shallow area could generate a corresponding amount of disturbance of the sea floor, we have an empirical relationship that the magnitude of the tsunami is in proportion to that of the earthquake. Actually, the statistical relationship between the tsunami magnitude 'm', and the earthquake magnitude 'M' is stated as

$$m = 2.61\ M - 18.44$$

The size of a tsunami can be also estimated if the earthquake magnitude is known.

The tsunami magnitude 'M', is

$$M_t = \log H + B$$

Where H is the maximum tsunami amplitude in metres observed by tide gauges and 'M_t' is determined as close as possible to the values of the moment 'M_w' of the earthquake that caused tsunami. From data of trans-pacific tsunamis 'B' is a constant for each pair of source region and observing region.

Types of tsunamis

There are two types – distant and local. For us only longer period (not the short period) front running waves are of concern at a coastal disaster (Fig. 4.17) site located at a great distance from the generating source.

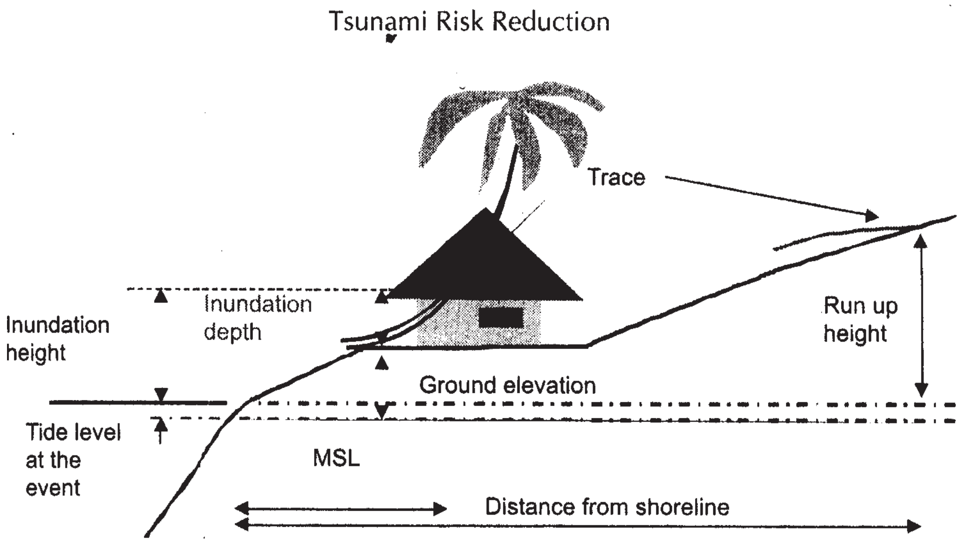


Fig. 4.17 : Tsunami run up and inundation, major items for tsunami survey.

Features of tsunamis

Since tsunamis are generated by physical disturbances they produce physical indicators of their pressure and intensity.

a) If a tsunami is generated by a large earthquake then the ground shaking is the clear indicator of its potential. Mild shaking usually does not initiate high amplitude tsunamis which create havoc.

b) Another indicator of a tsunami is an abrupt change in the sea level. As the exposed sea floor is rapidly filled by the approaching wave the tsunami produces a loud roar like a jet plane. At night this roar on the coastal plane is a reliable indicator. Although 99% of the tsunami deaths occur near the generating source, tsunamis can travel across on entire ocean basin without losing much power. Tsunamis originating in Chile have killed residents in Hawaii and Japan hours later. Tsunamis that visit distant shore lines come without the earthquake indicator but the waves cause sudden changes in sea level and create a loud roar as they approach the shore line.

Prediction of tsunamis

Tsunami warning systems are a combination of monitored detection sensors alongwith appropriate communication methods to alert people along vulnerable areas. The system is based on the fact that earthquake waves travel 25 times faster than tsunami waves. Thus, seismic waves emanating from a large earthquake arrive before the tsunami giving the community lead time to evacuate. Local tsunami warming development is urgently needed to complete the methodology in tsunami hazard mitigation.

Mitigation efforts in Tsunamis including hazard maps

Hyderabad in India has a tsunami warming system. From the information of the affected areas in the early part of this century (the Indonesia tsunami) effort should be made to map and delineate the Indian coastal areas according to the intensity/amplitude and the damage it caused. The tsunami, referred to above which hit Chennai coast caused intensive damage to the coast line. Accompanying the tsunami there must have been a prior movement. The event caused slight tilting of the physical disposition of the coast. It has caused an upliftment/elevation the shore line. The result is that when Chennai is now flooded due to rains etc. the logged water does not flow into the sea as easily as it did in the past. Consequently water stays on for a much longer period which might be responsible for spread of malaria and other epidemics in the city.

Community based mitigation

Once the areas of tsunami flooding hazard have been identified, a community wide effort of tsunami hazard awareness is essential to educate the residents. Then only it will be possible for the denizens take appropriate actions in the event of a tsunami. Awareness education must include at a minimum.

1) Creation of tsunami evacuation procedures to remove residents from the tsunami hazard zone, to a to[pographically higher level
2) Implementation of all education programme for schools to prepare students at all age levels
3) Periodic practice drills to maintain the preparedness level
4) Involvement of community organizations to educate all sectors of the population at risk.

5.2 Types of Tsunamis

There are two types of tsunamis, namely, distant and local. In most instances, the propagation of a wave system resulting from a distantly generated tsunami can be treated in a simplified manner. Relatively short-period tsunami waves are more easily damped by friction and breaking; therefore, only longer period front-running waves are of concern at a coastal site located at a great distance from the generating source.

The wavelength of a tsunami is much longer than the depth of the water. This leads to the system of long waves, while the frequency of dispersion of the wave depends on the velocity. Thus, a wave with shorter wave period propagates with slower travelling speed, celerity. Assuming the amplitude of a tsunami in the deep ocean to be infinitesimally small compared to the water depth allows us to assume linearity of the water movement. Therefore, from its generation in deep sea to its travel over the ocean, a distant tsunami can be solved with the aid of linear equations for long waves with wave dispersion effect and the Coriolis force included, described in the spherical coordinates with longitude-latitude system.

If there is a potential for locally generated tsunamis, the wave system and local wave propagation should be evaluated. Determi-nation of the wave system and propagation of a locally generated tsunami cannot be simplified in the same manner as a distantly generated tsunami. The long-wave approximation cannot be applied because the short-period waves are near the generating source and soliton fission happens on a long and mild bottom in a shallow. Any simplifying assumptions made for evaluating locally generated tsunamis should be carefully and critically examined and only used if they are demonstrated to provide conservative results.

TSUNAMIS IN JAPAN

Great damage and suffering have been wrought by tsunamis since ancient times along the coast of Japan. Loss of human lives is especially significant. For example, the 1896 Meiji great Sanriku tsunami is one of major ones, claiming 22,000 victims (Plate 2 on page 305). Repetitive onslaught in Japan has made tsunami, a Japanese word an international term for a series of waves generated by abrupt and large disturbances of the ocean surface due to earthquake, volcanic eruptions, landslides, slumps, and meteor impacts. Over 30% of the tsunami victims are in Japan. Although a tsunami is one of the most terrible natural disasters, it is possible that human loss can be reduced zero if evacuation to safe zone in the elevated area before the tsunami arrival can be undertaken, because sometime is left between the earthquake and the coastal attack. However, such evacuation is mostly inadequate at present.

The Japanese coastline rapidly changed due to the construction of wave breaks and seawalls after the 1959 Ise storm surge and 1960 Chilean tsunami. Rapid growth of the economy and industry resulted in a dramatic change in land use, human community and high density transport network along the coast. Various facilities have been built on the coast and a large number of fishing and leisure boasts and vessels including combustible large tankers are berthed in the harbours and are sea-faring. According to the result of earthquake and tsunami in Tokai, Tonankai and Nankai area by the special survey committee of the Central Disaster Management Council (CDMC) in 2003, tsunamis with more than 10 m wave heights affect the whole coastal area on the western Pacific coast of Japan, where the disaster reduction structures such as seawalls no longer offer full protection. Moreover, new patterns of damage are emerging in the form of large-scale fife and failure of power plants and industry and stop page of sea transport services. These are of great concern.

5.3 Features of Tsunamis

Indicator of Tsunamis

Since tsunamis are generated by physical disturbances, they produce physical indicators of their presence and intensity. Knowledge of these indicators can be used to mitigate the damage to a coastal community. If a tsunami is generated by a large earthquake, then the ground-shaking associated with the earthquake is a clear indicator of tsunami potential. However, at least 5% of the tsunamis are not generated by strong shaking earthquakes. These earthquakes are 'slow' and at-risk population may feel only a mild shaking. Another indicator of tsunami is an abrupt change in sea level. A rapid draw down of a harbour coastline well below low-tide level is the most reliable indicator of' an approaching tsunami. As the exposed sea floor is rapidly filled by the approaching wave, the tsunami produces a loud roar similar to a jet plane. If the tsunami occurs at night when the exposed seafloor cannot be seen, this roar may be the most reliable indicator that a tsunami is approaching the coastline. Although 99% of the tsunami deaths occur near the generating source, tsunamis can travel across entire ocean basins without losing much power. Tsunamis originating in Chile have killed residents of Hawaii, and Japan hours later. Tsunamis that visit distant shorelines come without the earthquake indicator but the waves cause sudden changes in sea level and create a loud roar as they approach the shoreline.

Propagation in Deep Water

Most tsunamis caused by undersea earth-quakes happen in the deep sea and propagate over the ocean. There are two important parameters for wave propagation: depth of the water relative to the wave length, which controls wave frequency dispersion and wave amplitude relative to the water depth, which is an indicator of non-linearity.

Let us take tsunami propagation in deep water. Since a wave length is larger than water depth and wave amplitude is negligible, we can assume that linear long wave theory can be used, which gives the following wave propagation speed, celerity:

$$c = \sqrt{gh}$$

where g is the gravity acceleration and h is the water depth. The 1960 Chilean tsunami reached the coast of Japan, 17,000 km far from the source, only 23 hours after the generation, propagating over the Pacific ocean at a depth of about 4000 metres with the speed of 720 km/h.

Once tsunami waves reach shallow water, they transform dramatically. The speed of a tsunami is a function of the water depth given by root of the gravity acceleration multiplied by the water depth, and it slows as it nears the shore. But because its energy remains almost constant, the height of the wave grows tremendously in shallow water. This is one of the shoaling effect, given by Green's law:

$$\frac{a_1}{a_2} = \sqrt[4]{\frac{h_2}{h_1}}$$

where a_1 and a_2 are the amplitude for wave height in h_i and h_2 respectively.

Another effect of shoaling is diffraction in which focussing the rays on the corn-shaped bathymetry concentrated on the reefs, bays. and undersea features such as canyons also play a role in modifying the wave, buffering or focussing its energy, or changing its direction. Reflected waves interact with each other.

Tsunamis in Shallow Water

As it nears the shoreline, the tsunami height increases and becomes comparable with the water depth so that the non-linearity in convection becomes significant. The shallow-water equations including the effect of convection and bottom friction is usually used. The theory assumes the hydrostatic pressure but takes the finiteness of the wave amplitude into consideration. The second-order phase velocity includes the effect of water surface elevation. This effect makes the higher portion of the wave proceed faster. The frontal wave slope becomes steeper. If the water particle velocity at the front exceeds the local phase velocity, the water projects into the air. Consequently, a breaking bore is formed. The non-linear influence between a tsunamis and a tide can be negligible because the difference of the wave period is too large to make interaction in the phase. However, influence of bathymetry in deep and shallow seas on the tsunami propagation is significant.

Seiche

Significant oscillations of a water body, that can be excited by tsunamis are called *seiches.* When the frequency of the incoming tsu-nami matches one of the local oscillation modes, resonant amplification leading to large motions may occur. The oscillations of the water body also arise from the continuous application of an excitation either to the water column at an entrance or over the water surface. Therefore, the maximum wave height could be often observed not at the first wave arrival but only after several wave attacks. In order to evaluate the possibility of the oscillation, the wave period of a tsunami and local oscillation modes should be known.

Run up

As the tsunami waves reach the shoreline or coastal features under consideration, they experience shoaling, steepening and possibly breaking. Whether or not the wave breaks, reflection, dissipation or transmission expends the energy contained in each wave. The primary result on a beach is run up, which is the vertical height above still-water level that the rush of water reaches. This will depend on the geometry and roughness of the structure of the beach, the water depth and slope fronting of the beach, and the incident wave characteristics

Sedimentation

Since a bottom shear by a strong tsunami current becomes significant in shallow water, a large deposition of sand sediment and erosion, could affect the safety features. Erosion causes a failure of breakwater and damages a nuclear facility along the coast and in a harbour. Especially sand deposition around cooling water structure especially the entry and outlet prevents normal operation.

5.4 Prediction of Tsunamis

Numerical Simulation

A tsunami starts with a complicated initial profile, transforms under the effect of complicated bottom topography and runs up and down on the land of complicated topography. In estimating tsunami hazard, it is a usual practice to carry out numerical simulation. In order to ensure stable computation and accurate results, special consideration is required. There are two FDM (Finite different Method) models: TUNAMI and MOST, and one FEM (Finite Element Method) as the standard numerical modelling. TUNAMI (Tohoku University Numerical Analysis Modelling for Investigation) was developed by DCRC (Disaster Control Research Centre), Tohoku University based on the linear and non-linear long wave theory with staggered leapfrog scheme in the Finite Difference Method. The MOST (Method of Splitting Tsunami) model, developed by Titov of PMEL and Synolakis of the University of Southern California, uses a finite difference method to divide its computational domain. MOST is the standard model used at the NCTR.10 The ADCIRC model, as modified by Baptista and Myers, utilizes a finite element method to divide its computational domain." The ADCIRC model is currently being used by the Oregon Graduate Institute, to develop inundation maps in Oregon.

Early Warning Systems to Alert at-risk Populations

Tsunami warning systems are a combination of monitored detection sensors along with appropriate communication methods to alert people along vulnerable areas. The system is based on the fact that earthquake waves travel 25 times faster than tsunami waves. Thus, seismic waves emanating from a large earthquake arrive before the tsunami giving the community lead time to evacuate. Warning systems are essential to warn communities that do not feel intense shaking from the earthquake and are desirable in areas where earthquakes frequently occur. Local tsunami warning development is urgently needed to complete the third step in tsunami hazard mitigation. Existing technologies of single-station seismometers and satellite communications could be utilized to build on the success of the Chilean system. Affordable and reliable local tsunami warning systems are the challenge of the new millennium.

Tsunami warning

The tsunami prevention system consists of. public education, inheritance of disaster culture, warning and evacuation, and relief system after the disaster. Early warning and evacuation is the best way to save human lives. For quick judgement of near-field tsunamis around Japan, the Japan Meteorological Agency uses the JMA tsunami forecasting chart, in which four kinds of warning messages (major tsunami, tsunami, tsunami alert, and no tsunami) are given on a calibrated maximum amplitude of seismic waves recorded on the standard seismograph and the arrival time difference between the P and S waves.

Although these tsunami warning systems have been working well and are appreciated, further refinement is necessary. One possible solution might be introduction of numerical tsunami simulations. A trial for near-field tsunamis with a supercomputer shows that only a few minutes are necessary to compute tsunami heights, with sufficient accuracy, at 200 m-intervals along the 500 km-long Sanriku coast. The use of numerical tsunami simulation for far-field tsunamis is more promising because of longer time for warning and dissemination to the people. The JMA started a new tsunami system with quantitative information of tsunami heights and arrival time in 1999.

When the earthquake with the possibility that the tsunami is generated occurs, JMA provide the tsunami warning or tsunami advisory according to expected tsunami height based on the data.

Tsunami warning system in the Pacific Ocean

Under the auspices of the Intergovernmental Oceanographic Commission (IOC), the Inter-governmental Coordination Group for the Pacific Tsunami Warning and Mitigation System was convened in 1968 (ICG/PTWS, formerly known as ICG/ITSU for International Tsunami). An international cooperative effort involving many member states of the Pacific region, ICG/PTWS meets regularly to review progress and coordinate activities resulting in improvements of the service (Plate 5 on page 306). The present members are Australia, Canada, Chile, China, Colombia, Cook Islands, Costa Rica, Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nicaragua, Papua New Guinea, Peru, Republic of the Philippines, Republic of Korea, Russian Federation, Samoa, Singapore, Thailand, Tonga, United States of America and Vietnam.

The PTWC serves as the operational warning headquarters for the Pacific Tsunami Warning and Mitigation System. It works closely with other international, sub-regional and national centres in monitoring seismic and sea level stations around the Pacific Ocean for large earthquakes and tsunami waves. The PTWS makes use of more than 150 high-quality seismic stations around the world to locate potentially tsunamigenic earthquakes, and accesses nearly 100 sea level stations globally to verify the generation and evaluate the severity of a tsunami. The system disseminates tsunami information and warning messages to designated national authorities in over 100 locations across the Pacific. Subregional centres such as the WC/ ATWC and NWPTAC provide regional alerts to the US west coast, Alaska and Canada, and the northwest Pacific and South China Sea regions, respectively.

5.5 Research on Tsunamis and its Mitigation

Field Survey after the Events

Many field investigations are conducted immediately after an event: e.g., Nicaragua in 1992; Flores Island, Indonesia, in 1992; Okushiri Island, Japan, in 1993; East Java, Indonesia, in 1994; Shikotan Island, Russia, in 1994; Mindoro Island, Philippines in 1994; Irian Jaya, Indonesia, in 1996 and Indian Ocean in 2004.

Members of the ITST (International Tsunami Survey Team) decided that a field survey was necessary as soon as possible to try and determine the true value of the maximum run up and to make an accurate map of the run up distribution along the coast. Subsequent investigations by international and local scientists included two onshore investigations by international teams (the First and Second International Tsunami Survey Teams and Kawata et al)." Another role of the ITST has been to advise the government and the survivors about the safety of this section of the coastline.

Paper 5
Climate Variabilities & Disaster Risk and Urban-Rural Risk Management

Unit 1 ❒ Climate Disasters & Agriculture

Structure

1.1 Impacts of climate disasters

Agricultural losses account for a substantial share of total damage resulting from weather related natural disasters in these countries.

The conceptual framework of the climatic disasters on agriculture is given in the schematic flow diagram (Fig. 5.1).

The negative effect of extreme weather can be summarized as loss of crops, damage to trees, damage to irrigation facilities and infrastructure, low income of farmers and communities, decrease in agri production, higher prices of seeds, salinization of soils, soil erosion, water logging, landslides and pest development. The positive effects on the other hand can be concluded as increased rainfall, which can be tolerated by some crops and trees, fixing of atmospheric nitrogen by thunderstorms, germination of native plant species from bushfires, cyclonic storms guaranteeing longer period of water availability and supplementation of off-site extra storage in rivers, lakes and reservoirs and alluvium for recession crops or off-season cultivation.

Potential impacts of climate change on agriculture :

Climate change model studies demonstrate that the potential climate variability has increased and climatic disasters have become more frequent. Negative economic impact on agriculture has also increased. In fact the vulnerability to climate change agriculture has been increasing in developing countries located in lower and warmer latitudes. In these regions, cereal grain yields are projected to decline under the predicted global warming.

Thus the low income developing countries may be badly hit by weather disasters. Areas in the passageway of rain bearing winds may however benefit from increased rainfall. Therefore it is necessary for a country to take advantage of the opportunities and to avoid the drawbacks of the climate change. One has to understand the critical conditions of the crops and their abrupt changes. For example a 2°C temperature rise can increase or aggregate crop yields (like Wheat, Rice, Corn or Soyabean) on a global basis while a 4°C rise leads to an overall decrease. On the other hand some models of semi-arid and subtropical regions show that even a 2°C rise can result in diminishing crop yield. That shows that all the elements of the changing climate system like temperature, precipitation patterns, evaporative demand on crops forced by warmer climate etc. must be studied in a systemic way to know the impact of net result. On that basis the opportunity provided by the impacts of global warming may be utilized. However a comprehensive understanding will be only possible if we have a three way investigation into climate

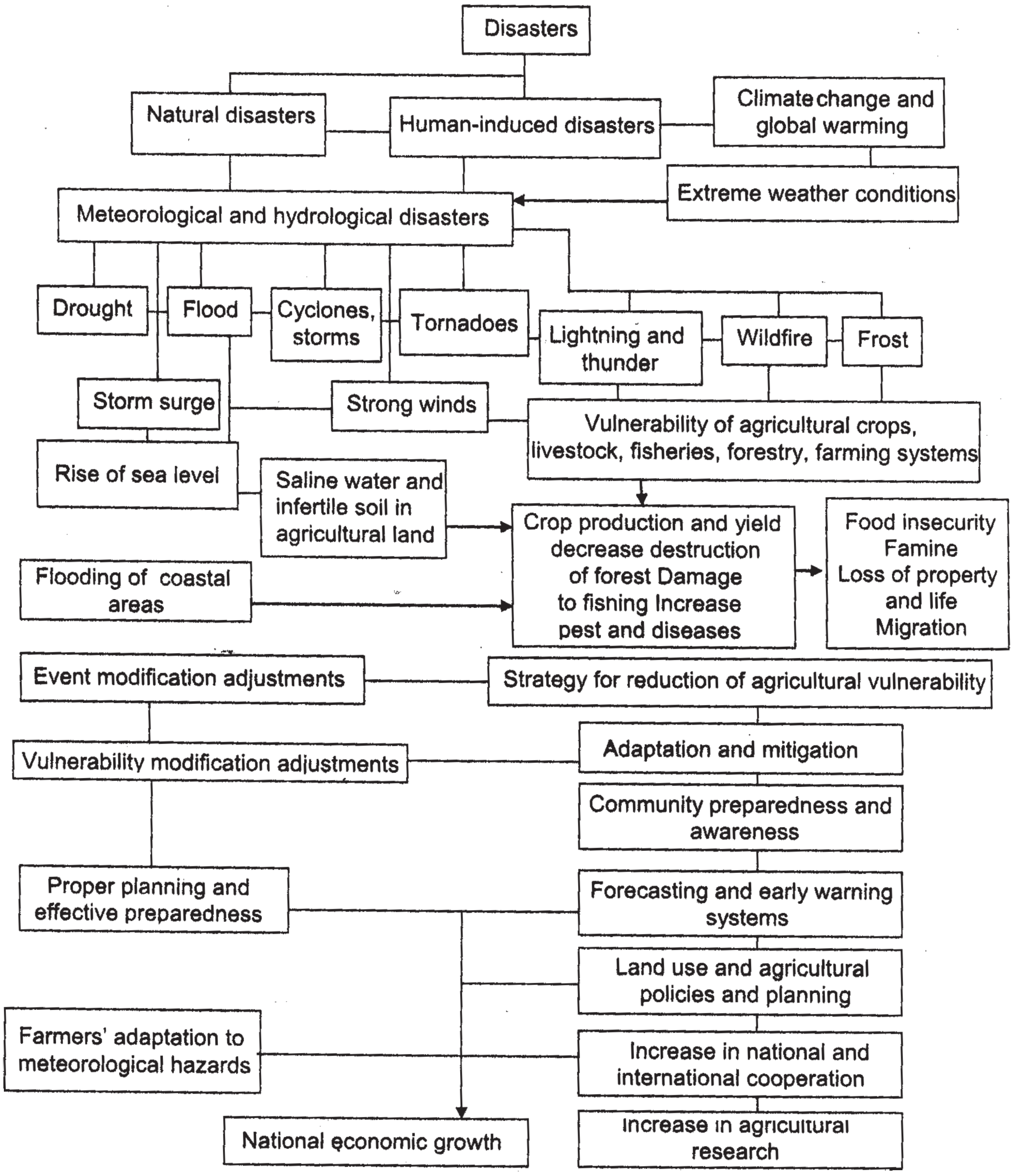


Fig. 5.1 : Conceptual framework of climatic disasters on agriculture.

change : (a) global (b) regional (c) local on an integrated interlinked and interdependent systems thinking approach.

Global warming is expected to extend to the length of the potential crop growing season in middle and higher latitudes in Canada, Russia, Mid and North Europe. In warmer and lower latitudes, increased temperature may accelerate the rate at which plants release CO_2 resulting in less than optimal condition for net growth. When temperatures exceeds the optimal for biological processes, crops often respond negatively with a sharp drop in net growth. If night time temperature minima rise more than the day time maxima, the night time respiration may also reduce the potential of yields. Another important effect of high temperature is accelerated physiological development, resulting in accelerated maturation and subsequent reduced crop yield.

Since agriculture is strongly influenced by the availability of water, climate change can alter rainfall, evaporation, evapotranspiration, run off and soil moisture storage. Changes in total seasonal precipitation and the pattern of variability can influence the potential impacts on agriculture. The overuse of chemicals in agriculture, may impact water and air quality. Warming conditions (of climate), drier soil and heavier (extreme!) precipitation, altered wind patterns may affect the agriculture practice in any location to a great extent. With global warming, the problem of pests will intensify. Thus the development and application of integrated pest management is called for. Climate change can impact agricultural sustainability in two ways – (a) diminish the long term ability of the agroecosystems to provide service (b) shift of agricultural systems to the present regions of natural habitats (of forests specially). Such a situation may prevent processes of natural selection of climatically adapted native crops etc. Thus the regional agricultural vulnerability may increase by the impact of warming. According to IPCC, global warming is predicted to cause thermal expansion of sea water, melting of ice and even glaciers. It results in a rise of sea level. The rise may be threatening agriculture in coastal low lying areas and saline water may enter estuaries and aquifers. In these conditions agriculture will not be tenable.

Emissions of greenhouse gases from agri sources (now – 15% of today's man made greenhouse gases) may increase in future.

Improvements therefore in the form of reduction of land clearing, biomass burning in the tropics are required. Moreover managing rice paddies and livestock to reduce methane is important task. The latter will improve upon fertilizer use efficiency to reduce the conversion of nitrogen to gaseous N_2O.

1.2 Agricultural vulnerability of climate disasters – Reduction strategies

- to introduce more cyclone, wind and storm resistant crops
- to instal proper drainage systems

- to plant forestry windbreaks or shelter belts (the windbreaks are being damaged by the humans for illegal settlements in the Sundarbans)
- to introduce salt resistant agriculture
- to introduce different types of agroforestry systems which contain different trees in the farming system
- to construct small scale embankments
- to plant trees and grassspecies for physical slope stabilization
- to improve watershed management
- to inculcate proper land use practice
- to conserve soil in an improved way and practice water management to reduce vulnerability to floods
- to set up canals and other improved drainage systems to protect arable lands from flood and tidal waves in the coast
- to supply improved boats and life saving devices to ocean going fishermen
- to change cropping pattern to minimize damage from storms cyclone and other weather related disasters
- to construct storm and cyclone resistant buildings and agricultural infrastructure
- to plant appropriate trees to hold the soil
- to construct earth platforms to raise ground levels of village homes
- to relocate communities in low risk areas – this is most vital.
- to effectively involve farmers in the development of new agronomic technologies and practices based on their traditional knowledge.
- Development of local coping strategies is most urgent for mitigation of impacts.

1.3 Mitigation of climate disasters vis-a-vis agriculture :

Climate disaster maps with appropriate information on the trend and occurrence of extreme events should be developed. These can be utilized for risk assessment and agricultural planning in a disaster prone zone. Developing a data base on agricultural disasters statewise and districtwise are the need of the hour. Use of GIS and if available, remote sensing for vulnerability mapping is most important with the participation of the target community/inhabitants.

Results of climate change impact model if found to be practically implementable may be utilized to develop adaptive agricultural response and livelihood adaptation practices. The farmers and the inhabitants should have a participatory training on (locally probable) perceptions of climate hazards on agriculture and their sustainable livelihood.

These farmers may also be trained on

- Introduction of late maturing crop varieties
- Switching cropping sequences

- Early sowing
- Adjusting training of field operations
- Conserving soil moisture through appropriate tillage methods
- Improvement of irrigation efficiency
- Layer based practical risk-management approach

On the other hand the government should build up standard agro meteorological stations in disaster prone districts to help the village community.

1.4 Global Warming and Agricultural Responses

The World Bank studies since 1990s have been harping on 2°C rise as their expectation in the world's average temperatures sooner than later. From the recent happenings in Europe, Australia and the American continents including Asia, it appears that initial anointing has begun. Monsoon has already become unpredictable in India and in places there is a reduction in crop yields. The pattern monsoon rainfall is undergoing change under global warming. The change in climate impacts agricultural pattern in two ways : (a) reduces the long term ability of agroecosystems to provide food crops and (b) by pattern shifts in agricultural regions to different ecosystems. Such a situation will deter the natural selection processes of climatically adapted native crops etc. Logically enough, it may increase the regional vulnerability (vulnerability is a human social character). It describes that he is liable to injury or open to successful attack. Agricultural vulnerability means that man is liable to agricultural injury that is agricultural/food production will be reduced. This effect will be further entranced if there are more ups and downs of Indian monsoon rainfall (4% - 12% variability) under warming. Thus it is necessary to comprehend the agricultural consequences of the climate warming. The unknown intensity of warming effects calls for prior planning and effective approaches of disaster risk management. But it is doubtful if adaptation will be possible without concomittant reduction of GHGs. In India, disaster risk management in agricultural production or food crop yields is so poor that >68% of India's cultivable land has become prone to drought entitled "Turn Down the Heat : Climate Extremes, Regional Impacts and the case for Resilience". The recent World Bank Report (2013) says that due to global warming, we often may find some areas under water and others without enough water for irrigation, drinking and power generation etc.

This report warns that in another two or three decades, reduced water availability due to precipitation level changes and falling groundwater tables (acute in Punjab, W. Bengal, Delhi etc.) is likely to aggrevate the Indian scenario — the water resources are already at a critical level and about 15% of the country's groundwater tables are overexploited. The above World Bank ecology report (2013) cites Kolkata and Mumbai alongwith Bangladesh as 'potential hot spots' threathened by extreme river floods, intense tropical cyclones, rising sea levels and very high temperatures (cyclones and very high temperatures have started showing up).

The report projects that increase in the frequency of low snow years in the Himalayas (signs are there already) might increase the risk of flooding and agriculture could be threathened. In India, 60% of the crop area making it highly vulnerable to climate induced changes in rainfall. With cloud bursts increasing in frequency in recent times, the adequacy of food production may be impacted upon. Moreover with persistent increase in warming, water in the major river basins may be reduced which may again influence the food production in the country. Therefore 'Limiting Global Warming i.e.Reduction of Greenhouse Gas Emission' is the key.

Unit 2 ❐ Risk Management of Forest Disasters

Structure

2.1 Introduction

It is held that to understand disaster management and disaster risk reduction, forest management is the key pathway (Fig. 5.1). Therefore the focus of our study should centre on two questions : i) how do forest and forest management reduce disaster risks? ii) how do they help in the vulnerability of man as well as the related natural resource when exposed to hazards? In other words, what role do forests and forest management play in reducing human risk and vulnerability to natural disasters is to be analyzed. Secondly we should know the implications of forest degradation in terms of human security. The elemental relationship between forest resources, forest management and disaster risk reduction is presented in Fig. 5.4. A forest is a storehouse of biological diversity. The latter gives rise to economic activities involving among others food production, security and economic benefits for a livelihood. Hence we recognize that the economic viability of the forest sector is a prerequisite to safeguarding the environmental, social and cultural functions of the resource base.

For sustainability of the forest, an understanding of the concerned ecosystem-stability-resilience, elasticity, resistance to disturbance is required. Another event that needs to be focused is forest fire, which can be a large-scale disturbance to a forest ecosystem. It leads to widespread degradation. In addition human interventions like tree felling and unsustainable hunting practices promote disintegration of forests. On the other hand,

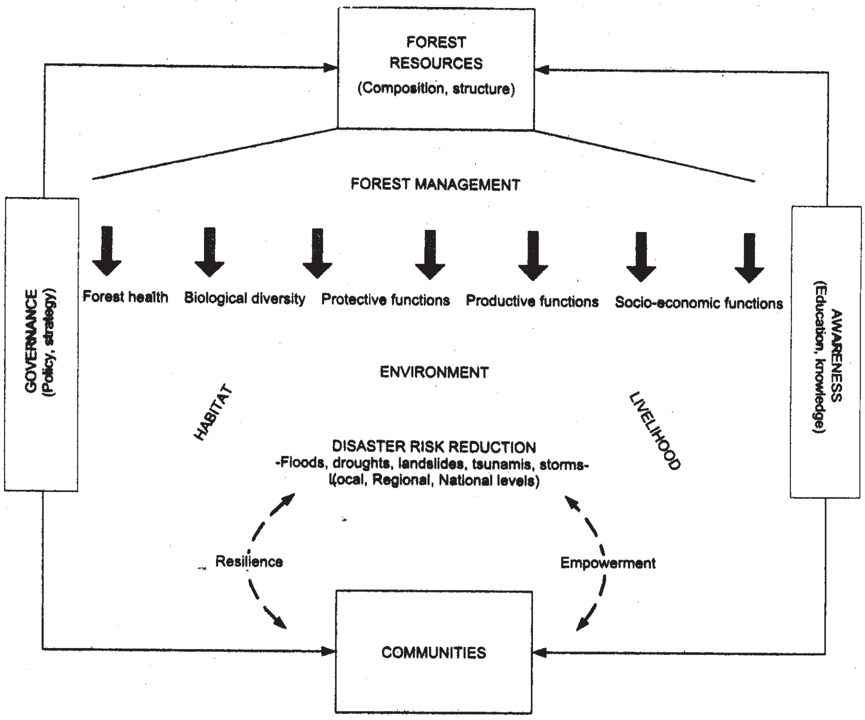


Fig. 5.4 : Relationship between forest resources, forest management and disaster risk reduction

promoting diversified farms with agroforestry in buffer zones can enhance forest integrity.

Thus the health and vitality of forest will have to be maintained to reduce the disaster risk and to withstand natural disaster.

2.2 Protective functions of forest resources

a) Prevent wind erosion
b) Protect from avalanches
c) Act as filters for air-pollution
d) Protect water resources
e) Protect coastal areas
f) Influence the climate

Socioeconomic functions of forest resources – forests provide a wide range of economic and social benefits to humankind. These include contributions to the overall economy and investments in the forest sector. They also include the hosting and protection of sites and landscapes of high cultural, spiritual or recreational value. Maintaining and enhancing these functions is an integral part of forest management. Another important element that needs to be considered in this socioeconomic function of forests is ecotourism, which is a segment of 'nature tourism'.

2.3 Forests, deforestation and climate change

Forests play a very important role as far as carbon flux is concerned. More carbon is sequestered and conserved by forests than any other terrestrial ecosystem. This amount accounts for 90% of the annual carbon flux between the atmosphere and the earth's land surface.

Currently global deforestation occurs at a fast rate of around 13 million hectares per year. Deforestation is a major contributor to climate change and emissions from deforestation constitute the main source of greenhouse gases from many developing countries and at a global scale are higher than the total amount produced by the transport sector annually. Projections indicate that approx. 10%-20% of current global forestland will be converted to other uses by 2050 with large ill consequences for the global carbon cycle. The situation is grim. Forests and climate change are intricately linked and forestry can play a key role in contributing both to climate change, mitigation and adaptation. The question then is how strongly deforestation will affect the vulnerability of people.

2.4 Desertification and Deforestation

Desertification is referred to as a process resulting from human interventions (felling of trees etc.) and natural factors, such as overexploitation of land, overgrazing, mechanized farming, bad irrigation practices, illegal and excessive logging, bush and forest fires and deforestation due to population increase; alongwith these human activities, a range of climatic factors are believed to influence the process of land degradation.

Combating desertification involves wide range of measures. These measures would contribute to combating poverty, to structural reforms and to development.

Desertification spreads slowly from a small nuclei and gradually lays waste large areas. To control and halt it, immediate action has to be taken at the initial stage – the measures include reafforestation after rejuvenating the soil and re-afforestation in consonance with the then climate situation. Halting desertification becomes increasingly expensive; eventually recovery may be impossible. Drought is often considered as the cause of desertification but it is not. It only triggers the crisis, droughts, deforestation and overgrazing may cause progressive erosion of the forest.

Population pressure on the forest margins also cause deforestation and degradation of land. In Ghana, one of the causes of land degradation is bush burning, a result of inappropriate farming methods, negative cultural practices and those of poor grazing management. In Zimbabawe, environmental degradation includes river bank erosion, siltation, gully erosion and wetland depletion. Destruction of ecosystem and loss of biodiversity result in perennial water depletion as it happened in Mupashi project at

Zimbabawe. In China, desertification is a big problem – 3600 km^2 of grassland is taken away by the desert every year causing a loss of US$ 50 billion per year to the Chinese economy with 24000 villages abandoned. This desertification is accelerated due to :

i) Population growth
ii) Economic development
iii) Poor protection of ecosystem because of lack of awareness
iv) Overgrazing
v) Overcutting of fuelwood

2.5 Landslide-related events

An increase in forest cover especially on mountain slopes can reduce the risk of landslide and flooding associated with extreme rainfall events.

Areas covered with shrubs are found to be much less affected than those with grass fallow, croplands or bare soil. The differences of effects are noted to be dramatic in areas of steep slope.

Agriculture activity and the associated removal of deep rooted permanent vegetation increase the landslide hazard on steep sites.

The likelihood of landslides is significantly influenced by slope and land cover.

Moreover proper ecosystem management goes a long way in reducing the risks and vulnerabilities associated with typhoons (study from Typhoon 23, in Japan in 2004 – Tokage typhoon that hit in Japanese Island leading to landslide disasters).

In appropriate Ecosystem Management – entailed below may lead to quickening of desertification :

vi) Deforestation and destruction of vegetation are caused by reclamation on steppe and desert sleppe plus pasture land
vii) Inappropriate farming systems on slopes can cause deforestation
viii) Degradation of vegetative coverage may lead to deforestation

To combat desertification at such a stage now calls for sectoral and cross sectoral environmental protection activities.

Flooding and deforestation

The problem of deforestation is related to landslides or the latter may be caused by the former but the relationship between deforestation and flooding is complex.

In the case of the Himalayas, in relation to flooding in say Bangladesh, logging for timber is often considered to lead to more rapid rainfall run off, silting of rivers and occasionally landslides. Other factors are the inappropriately constructed associated roads, causing slope instability and vegetation loss. Another factor that may increase the rate of deforestation is land shortage in upland areas, as people clear more land for agriculture, or damage trees for fuel and fodder.

It is more or less presently agreed that establishing a connection between deforestation and increased flooding is uncertain. However in a broad perspective, it may be said that there is certainly a detrimental impact of deforestation on environment but in terms of increasing vulnerability, it may play a non-negligible role.

2.6 Forests, forest management and disaster risk reduction : Lessons

Ecosystem management in the realistic terms, contributes to more effective reduction of disaster risks. They can mitigate the impact of most natural hazards such as landslides, hurricanes and cyclones.

Tsunami-related events

Among the then preliminary lessons learned from tsunami, 'careful coastal land use planning is essential to minimize risk' is most recognized.

Mangrove forests on the coast or shelter belt plantations of Casuarina equisetifolia are reported to be effective natural barriors if the trees are mature enough to withstand the tidal waves. It has been observed that coral reefs and mangroves are able to absorb (tsunami) wave-energy and that sand dunes bound by roots are much more resistant to water and wind than bare sand.

Storm related events

It has been reported from Nicaragua and Guatemala that farms using agroecological practices including agroforestry can withstand the impacts of hurricane Mitch (1998) better than those using conventional farming methods.

Mangrove forests can protect the inland from typhoon as was noted in Vietnam when the typhoon Weekong hit the coast in 2000.

2.7 Appropriate Environment/Ecosystem Management to help in the orientation of appropriate disaster risk management

In all the previous chapters, we have often dwelt on the importance of understanding the environmental/ecological system of an area. The point has been stressed and it has been commented that appropriate ecosystem management is a precursor to a successful disaster risk management. In this context a brief discussion on the optimal approach to ecosystem management is put forward :

Ecosystems are the productive engines of the planet – communities of the living species (including men) that interact with each other and with the physical setting they live in (forests, grasslands, rivers, lakes maintains, coastal and deep sea waters, islands, even cities). Each ecosystem encodes the lessons of survival and efficiency as countless species scramble for sunlight, water, nutrients and space. It is difficult, almost impossible, to recreate the natural life support system that ecosystems provide, should we damage them beyond their capacity to rebound.

In every respect, human development and human security are closely linked to the well being and productivity of ecosystems. Our future rests squarely on their continued viability.

An ecosystem management approach reorients the boundaries that traditionally have defined our management of ecosystem. It emphasizes a systemic approach, recognizing that each ecosystem functions as whole entities and need to be managed as such (holistically), not in pieces.

An ecosystem approach takes the long view, it respects ecosystem processes at the microlevel but sees them in the larger frame of landscapes and decades working across a variety of scales and time dimensions.

An ecosystem approach includes people. It integrates social and economic information with environmental information (very relevant for a disaster risk scenario) about the ecosystem. It thus explicitly links human needs to the biological etc. capacity of ecosystems to fulfill these needs (in a disaster risk scenario, the linkages must be understood so that human modifications of ecosystems may be appropriate).

An ecosystem approach maintains the productive potential of ecosystems. The human endeavour should be to put pressure on or increase the capacity of the ecosystem to produce the desired benefits of the future.

An example :

Ecosystem approach to forest management :

- Maintains the forest ecosystem as an interconnected whole, while allowing for sustainable commodity production.
- Maintains future options.
- Aims to sustain ecosystem productivity over time.
- Works at the ecosystem and landscape level.
- Focus on inputs and processes such as soil, water, Biol. diversity and ecological processes.
- Strives for management that mimics natural processes and productivity. It is a process which should be taken care in a post disaster scenario (recovery).
- Considers all species-plant and animal important.
- Strives to avoid biodiversity loss and soil degradation (work in post disaster recovery management).
- Views forests as a natural system, more than the sum of its parts (flood, earthquakes etc. are also natural system with causal linkages).

- Values cost effectiveness and social acceptability (Disaster Risk Management should have an affordable cost and must be accepted by the concerned community/ies).
- Involve all stakeholders in ecosystem management. The villagers are to be asked and empowered to manage the forest ecosystem sustainably.
- There is a need for an integrated assessment of ecosystem and disaster risk with probable causal links.
- Pre & post monitoring of ecosystem variables and/or environmental indicators for years together can help in fully restoring the ecosystem after natural disasters.
- Fill-in the information gaps pertaining to the ecosystem.

Introduction

The first well-regulated management approaches were introduced around the eighteenth century, more or less aiming at assuring a sustainable provision with timber. Today, worldwide forestry experiences a considerable change of its role and socio-cultural acceptance, which leads to a regionally diversified self-understanding of forest management concepts. An ecosystem-based management taking multifunctionality of forests on landscape level into account became one of the central, but also sometimes misleading ideas. Multipurpose forest management concepts have to consider a broad range of ecosystem attributes and bridge conflicting management objectives.

Research and experience have shown that forest ecosystems' play an important role in reducing the vulnerability of communities to disasters, both in term of reducing their physical exposure to natural hazards and providing them with the livelihood resources to withstand and recover from crises. The degradation of these ecosystems is exacerbating vulnerabilities around the world. Many reports, in relation with disaster management, highlight this resource degradation, or mainly the case of deforestation. Others show that forest resource degradation and deforestation lead to climate uncertainties and climate change.

Although the inherent links between disaster reduction and environmental management are recognized, little research has been undertaken on the subject. The general lack of empirical work and scientific analysis poses a barrier for the development of knowledge based policies and strategies for mitigation. Furthermore, the concept of using environmental tools for disaster reduction has not yet been widely applied by many practitioners. These facts lead to the importance of considering forest management in understanding disaster management and in particular disaster risk reduction. The questions to be answered are:

- How do forests and forest management reduce disaster risks?
- How do they help to reduce the vulnerability of humans, as well as the related natural resource itself to hazards?

In other words, what role do forests and forest management play in reducing human vulnerability to natural disasters and what are the implications of forest degradation for human security?

In trying to answer to those questions, this chapter examine several key points relating to the relationship between forestry/forest management and disaster risk reduction, which is one of the components of disaster management, main purpose of this book. Since the general concept of disaster management and particularly disaster risk reduction is already presented in the previous chapters, the present chapter will focus more on the relationship between forest management and disaster risk reduction.

Forestry is not an isolated sector; it is to be studied alongside agriculture, fisheries, civil engineering and other fields. In this chapter forest management in its forestry dimension will be focused to understand its relationship and contributions to disaster risk reduction.

General Concepts

Sustainable forest management relies on appropriate understanding of the principles of disaster risk and vulnerability. In the following sections, the general concepts of disaster risk related to forest management are discussed.

Natural Disaster and Disaster Risk

The term 'natural disaster' is 'often used to refer to natural events such as earthquakes, hurricanes or floods. However, extreme natural events are not disasters until a vulnerable group of people is exposed. These natural phenomena are referred to as "hazards" and are not considered to be disasters in and for themselves. A natural disaster is the combination of *hazards* with *vulnerability* to these natural phenomena. Since *risk* is referred as the expectation value of losses (such as death, injuries or properties) that would be caused by a hazard, disaster risk is thus considered to be a function of hazard, vulnerability and exposure. The latter is referred to as "that which is affected by natural disasters such as people and property". Therefore, disaster risk reduction is the reduction of the level of vulnerability while keeping exposure as.far away from hazard as possible by relocating populations and property. Disaster in this context, could be defined as "a combination of the factors that determine the potential for people to be exposed to particular types of natural hazard" depending fundamentally on how social systems and their associated power relations impact on different social groups.'

The level of risk in relation to natural disasters in a society is determined by the level of vulnerability combined with the level of probability and intensity of the occurrence of a natural hazard. Thus, risk reduction refers to activities taken to reduce both vulnerable conditions and, when possible, the source of the hazard.

2.8 Forest Management and Sustainable Forest Management

Forest management covers forestry aspects and other downstream technical considerations (including activities, technology and infrastructure requirements, specialized personnel needs). Sustainable forest management (SFM) and how to achieve it are much discussed issues on the international environmental agenda these days. Sustainable forest management aims to ensure that the goods and services derived from the forest meet present-day needs while at the same time securing their continued availability and contribution to long-term development. Also, as defined by the United Nations through the Economic and Social Council, "in general terms, sustainable forest management deals with the administrative, economic, social, legal, technical and scientific aspects of the conservation and sustainable use of forests within the framework of technically sound and politically accepted national land-use plans. It implies various degrees of human intervention, ranging from action aimed af safeguarding and maintaining the structure and function of forest ecosystems, to favouring socially or economically valuable species or groups of species for the improved production of goods and environmental services".

In addition, economic viability, including the environmental and social benefits deriving from forests, is a pre-requisite for wider adoption of sustainable forest management practices. Enhancing economic benefits from forests and trees, and their equitable distribution, are also critical factors in the development of forested areas. Marginalization of forestry in social and economic development may fuel armed conflicts, whereas sustainable forestry that creates employment and generates income can help to avert the emergence of conflicts and promote post-conflict rehabilitation. These facts show the importance of forestry and sustainable forest management for social, economic, technical or administrative aspects.

Before analyzing the relationship between forest management and disaster risk reduction, it is important to know key trends of forest resources, their functions and benefits. While many trends remain alarming, it is clear that there are also many positive developments regarding forest resources, their management and uses. To better understand this part, key findings according to six themes defining sustainable management as presented in the Global Forest Resources Assessment 2005 (hereafter FRA, 2005), which is one of the most comprehensive assessment to date, are presented in this section. In addition to providing information on 'traditional variables' such as forest area change and deforestation, first thematic element of sustainable forest management, FRA 2005 includes detailed information on key aspects related to biological diversity, forest health and the productive, protective and socio-economic functions of forests. In addition to FRA 2005, FAO also published the *State of the World's Forests,"* which presents a global picture of the forest sector, providing the latest information on activities and developments. In this publication, FAO highlights challenges and opportunities related to some of today's key emerging issues. The theme of the 2005 edition—"realizing the economic benefits from forests" —recognizes that the economic viability of the forest sector is a prerequisite to safeguarding the environmental, social and cultural functions of the resource'.

Forest Resources

Total forest area in 2005 is estimated to be less than 4 billion hectares equivalent of

30% of total land area. Deforestation accounted for 13 million hectares per year and was mainly due to conversion of forests to other land-use especially for agriculture. However, net loss of forested area have been reduced by forest planting, landscape restoration and natural expansion of forests. Moreover, findings showed that forest biomass decreased in Africa, Asia and South America during the period 1990-2005, though an increase has been registered in all other regions. Globally, carbon stocks in forest biomass decreased by 1.1 Gt of carbon annually, owing to continued deforestation and forest degradation. However, it is partly offset by forest expansion (including planting) and an increase in growing stock per hectare in some regions.

Biological Diversity

The term *biodiversity* (which originated from *biological diversity)* "refers essentially to the diversity of living organisms, the genes they contain, and the communities to which they contribute".

Globally, in 2005, 11% of the total forest area—corresponding to 400 million hectares— were designated for the conservation of biological diversity as the primary function. The increase of forest devoted to conservation of biodiversity was 30% (corresponding to 96 million hectares) higher than that of 1990. In addition, FRA 2005 data confirm that forest biodiversity conservation concerns have encouraged significant policy responses and, in particular, the setting aside of increasing areas of forest for conservation purposes.

The need to integrate biodiversity into the economy of the relevant communities has been discussed and various values of biodiversity should be captured and realized at the local level to give the right incentives to those that are nearest to guard it. To conserve the world's biological diversity, up to 102,102 sites figure in the *UN Lists* covering 18.8 million km^2—among which 17.1 million km^2 constitute terrestrial protected areas, and only approximately 1.64 million km^2 comprise marine protected areas.

Species numbers at different scales, and genetic, organismal or ecological diversity. are among the proposed measures of biodiversity relevant to nature-conservation policies. Approaches that more clearly address not only structure, but also its relationship with ecosystem functioning, are those that emphasize keystone species or the number of functional groups, or those that apply weighted indices such as Simpson's and Shannon's diversity indices. Patchiness, or fragmentation, in a forest community is also a measure of spatial diversity. However, conservation of biological diversity is not only perceived to conserve the species and genes of valuable resources for the sake of only conservation, but is also the guarantee for forest-depending lives and livelihoods.

There are multiple links between bio-diversity, food, nutrition and human health. Biodiversity at the genetic and species levels provides the basic components of nutrition, including energy, protein, fats, minerals and vitamins, as well as bioactive 'non-nutrient' functions. In addition, cultivated species may be complemented by harvested wild species that can be of particular significance for indigenous communities and for poor and vulnerable communities, especially in times of shortage of main staples. In addition to its role in supporting and sustaining food production, biodiversity, by underpinning dietary diversity, has a role to play in addressing both under-nutrition associated with poverty, and obesity-related diseases associated with urbanization in developed and developing countries.[35]

In some regions, biological diversity is essential for sustainable food production and food security. The loss of diversity could make the local environment more ecologically unstable, affect sustainable food production, local community control and access to genetic resources. A case study in Zimbabwe showed that biological diversity has an important role related to traditional healing by using medicinal plants. Local communities are aware of this importance and leading the Zimbabwe National Traditional Healers Association (ZINATHA) and many other groups in Zimbabwe to "actively promoting a draft legislative proposal that can protect the local community's intellectual property rights and the country's diverse biological wealth".

From India, the forest management approach in Orissa (Dhoni) is an example where participatory management of the native population sustained and enrished the forest resources. Promoting the inherent communities' property rights in their natural environment is emphasized.

Forest Fire — An Initiator of Disaster :

In Honduras, S. America, Hurricane Mitch killed thousands of people, caused significant damage to forests. In 2012, Tasmania in Australia was ravaged by, a soaring forest fire. If the fire is not caused by storms, it can be human induced or accidental, specially in the latter instance in a drought hit region. Interestingly the ramifications of forest fires may be predicted by taking recourse to Fractal Geometry.

Agroforestry :

Agroforestry, defined as a set of land-use practices involving the deliberate combination of trees, agricultural crops/animals on the same land management unit in some form of spatial arrangement or temporal sequence, is getting more and more attention. Cultivating trees in combination with crops and livestock is an ancient practice. However, several factors have contributed to a rising interest in agroforestry since the 1970s: the deteriorating economic situation in many parts of the developing world; increased tropical deforestation; degradation and scarcity of land because of population pressures; and growing interest in farming systems, intercropping and the environment. Most research on agroforestry has been conducted from the biophysical perspective, but socio-economic aspects are gaining attention. In addition, other reports indicate that agroforestry can provide a greater range of environmental benefits. For example, in areas adjacent to national parks in Sumatra, Indonesia, households with diversified farming systems, including mixed perennial gardens, depended much less on gathering forest products than did farms cultivating only wetland rice. Thus, tree felling and unsustainable hunting practices in the nearby parks were reduced. The findings suggest that promoting diversified farms with agroforestry in buffer zones can enhance forest integrity.

Protective Functions of Forest

In 2005, the extent of forests with protection as their designated primary function was 348 million hectares (Table5.1), corresponding, to about 9% of the global forest area. At the same time, 1190 million hectares of forest were identified as having a protective function as one of the designated functions, indicating an increased awareness of the important role forests play in soil and water conservation, avalanche control, combating desertification and coastal protection. The world's forests have many protective functions, amongst others :

Prevent wind erosion: Wind-rows and shelter-belts reduce loss of nutrient-rich topsoil. The latter also helps dune stabilization.

Protect from avalanches: In the Alpine countries of Europe forests offer protection from snow avalanches.

Act as filters far air-pollution: Trees intercept and trap wind-borne particulate matter, with a condition that the pollution does not harm or kill them. Dust, ash, pollen and smoke that adversely affect human health and visibility can be 'raked' from the atmosphere, and then washed to the ground by rainfall or snow.

Protect water resources: Forests protect water resources by reducing surface erosion and sedimentation, filtering water pollutants, regulating water yield and flow, moderating floods, enhancing precipitation and mitigating salinity.

Protect coastal areas: Forests in coastal areas, especially mangroves, reduce the shoreline erosion, siltation and impacts of storm surges and tsunamis. It is reported that mangroves also filter and remove some of the nutrients and heavy metals coming from upstream land uses and industry, immobilizing them in the mud, as long as they prove non-toxic to the mangroves themselves.

Influence the climate: Forests reflect less heat back into the atmosphere than other types of land use that have more bare soil and less green cover. Trees also play an important role in the global carbon cycle. Furthermore, during the cold season, they obstruct, filter and deflect wind, reducing wind chill. The functions of reducing wind velocity, moderating soil temperature and increasing relative humidity are also beneficial in agroforestry systems.

Table 5C1 : Area of forest designated primarily for protection in 2005.

Region/subregion	Information availability			Area of forest designated primarily for protection	
	Countries reporting	Forest area (1000 ha)	Percentage of total	Forest area (1000 ha)	Percentage of forest area
Eastern and Southern Africa	16	211,181	93.2	6,018	2.8
Northern Africa	13	125,667	95.9	12,567	10.0
Western and Central Africa	15	118,280	42.6	2,206	1.9
Total Africa	44	455,129	71.6	20,791	4.6
East Asia	5	244,862	100.0	66,992	27.4
South and Southeast Asia	17	283,126	100.0	59,097	20.9
Western and Central Asia	23	43,579	100.0	13,069	30.0
Total Asia	45	571,567	100.0	139,158	24.3
Total Europe	36	991,192	99.0	90,488	9.1
Caribbean	9	3,489	58.4	1,291	37.0
Central America	7	22,411	100.0	1,068	4.8
North America	4	677,464	100.0	986	0.1
Total North and Central America	20	703,364	99.6	3,345	0.5
Total Oceania	14	203,467	98.6	502	0.2
Total South America	13	831,540	100.0	93,559	11.3
World	172	3,756,260	95.0	347,842	9.3

Some countries such as Greece and Kazakhstan reported 100% of the forest and other wooded land being managed primarily for soil protection.

Many countries are making efforts to increase awareness of stakeholders on the importance of protective functions of forests. Indian forests particularly in E. India are good examples. Although Japan stated that all forests are expected to perform multiple functions, importance is given to the function of protection. Thus, as of March 2002, there were 17 types of protection forests, and 8.9 million hectares of forests or one third of the nation's land area, designated as protection forest, of which 72% is for water resources conservation. Water resource conservation is further divided into three functions: flood mitigation, water resource storage and water purification.

In China, during the Tenth Five-Year Plan period, the natural forest protection project succeeded in securing 8 million hectares of forest for ecological benefits, enabling 93.33 million hectares of forest resources to recover. The project to reforest cultivated land created 21.33 million hectares of forests, among which 5.38 million hectares were ecological forests transformed from cultivated farmland, 12 million hectares were planted on barren hills and wasteland, and 1.33 million hectares were created by closing off hillsides for afforestation. In addition, 6.67 million hectares of land were covered in various ways by efforts to control the sources of dust storms in the Beijing-Tianjin area.

2.9 Forests, Deforestation and Climate Change

Forests play an important role as far as carbon flux is concerned. According to the IPCC, forest ecosystems contain the majority (approximately 60%) of the carbon stored in terrestrial ecosystems. This leads to the fact that more carbon is sequestered and conserved by forests than other terrestrial ecosystems; this amount accounts for 90% of the annual carbon flux between the atmosphere and the earth's land surface.

Carbon is stored as biomass (in trunks, branches, foliage and roots) and as organic carbon in the soil. Globally, the soil carbon exceeds the carbon stocks in vegetation by a factor of about five, but this ratio varies among different ecosystems. For tropical forests the ratio is almost balanced, which aggravates the effect of the current and continuing loss of tropical forests. By far the greatest sources of forestry-related emissions are clear-cutting and logging in forests, which are responsible for about 20% of global, human-induced emissions.

Desertification and Deforestation

According to the United Nations Convention to Combat Desertification (UNCCD), "desertification means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" and "combating desertification includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development..." The term 'desertification' is used to refer to a process resulting from anthropocentric and natural factors, such as over-exploitation of land, overgrazing, mechanized farming, bad irrigation practices, illegal and excessive logging, bush and forest fires and deforestation due to population increase; along with these human activities, a range of climatic factors are believed to influence the process of land degradation. Due to these multiple causes, halting desertification involves a wide range of measures and contributes to combatting poverty, to structural reforms and to sustainable development.

Desertification spreads slowly from small nuclei until it eventually lays waste large areas. Desertification feeds upon itself, creating arid areas even in areas where previously rainfall was plentiful. Treatment in the early stage has a good chance of success. But if no action is taken, either because people are too poor or because of a lack of political will, halting desertification becomes increasingly expensive. Eventually recovery may be impossible. Drought is sometimes considered as the cause of desertification. However, it is now widely agreed that, 'droughty triggers a crisis but does not cause it.' Overcultivation and overgrazing weaken the land, allowing no margin when drought arrives. Thus high human pressure will continue during the drought, leading ultimately to even greater and more visible damage to the land and the deaths of large numbers of people and animals.

Many scientists make efforts to clarify the link between desertification, drought and deforestation. In Djibouti, droughts, deforestation and overgrazing have all caused progressive erosion of the forest. This is the case of the Day Forest—a relic of a bygone era, being 1.2 million years old and containing around 60% of the country's biological diversity. The principal problem now is that many of the forest's main ligneous species—such as junipers, which help harness that so mist it can get sufficient water supply—are losing their natural ability to regenerate. In Ghana, one of the causes of land degradation is bush burning, which is a result of inappropriate farming methods, negative cultural practices and poor grazing management practices. Land degradation has a direct effect on malnutrition among children. In Zimbabwe, environmental degradation includes river-bank erosion, siltation, gully erosion and wetland depletion covering 2.4% of the total area. In addition, 3.1% of the total land area suffered from gold panning and mine dumps. These problems at rural district council level were amplified at community level. This is illustrated by the Muposhi Project, where environmental degradation, the destruction of ecosystems and loss of biodiversity that occurred between 1949 and 2004 resulted in perennial water depletion. In China, desertification is a critical problem: the deserts are extending with a remarkable speed (3,600 km^2 of grassland is taken by the desert every year), causing a loss of $50 billions per year to the Chinese economy, with 24,000 villages abandoned. Desertification has been accelerated by th population growth, the pressure from economic development, poor awareness of the importance of the protection of ecosystem, over-grazing, over-cutting of fuelwood, deforestation and destruction of vegetation caused by reclamation on steppe, desert steppe and pasture land, inappropriate farming systems on slopes and the degradation of vegetative coverage.

Efforts are currently underway to combat desertification in various regions of the world. By early 2002, 23 African countries finalized, validated and adopted their National Action Programmes. In Kenya as in many other countries, the National Action Programme has been included in a number of sectoral environmental protection plans. Additionally, it is being implemented under various sectoral and cross-sectoral activities.

Flooding and Deforestation

In many countries, there is a widespread belief, including among many foresters, that forests can prevent or reduce floods. Therefore, an immediate, frequently drawn conclusion is that floods occur because forests have been cleared or degraded. Can flooding be increased (frequency/intensity) as a result of land being cleared of vegetation and forest in the rainfall catchment? This is a widespread assumption by those concerned about flooding.

It is reported that direct links between deforestation and floods are far from certain and "'hydrological systems are so complex that it is extremely difficult to disentangle the impacts of land use from those of natural processes and phenomena"; in the case of upland/lowland as well as forest and flood relationships, existing knowledge is frequently based more on perceived wisdom, or myths, than on science. In the rush to identify the culprits for the most recent disasters, assumptions are made about processes in one region based on observations from other regions, which often have quite different, environmental characteristics, or by extrapolating from small to large scales.

Unlike the problem of deforestation in relation to landslides where there may be a much more immediate connection between cause and effect, the causes for deforestation and flooding are more complex and are often widely taken for granted. Deforestation and 'de-vegetation' have many causes and there are significant differences in the effects of various patterns of land use and associated deforestation, leading to the need for analyzing this concept.

In the case of the Himalayas, in relation to flooding in Bangladesh for example, logging for timber is often considered to lead to more rapid rainfall runoff, silting of rivers and sometimes landslides. Other factors are the inappropriately constructed associated roads, causing slope instability and vegetation loss. Another factor that may increase the rate of deforestation is land shortage in upland areas, as people clear more land for agriculture, or damage trees for fuel and fodder.' Some scientists argued that the evidence for a strong connection between deforestation and increased flooding is uncertain, and that hydrological data do not demonstrate that good vegetative cover in large river basins is necessarily a factor in preventing rapid runoff of storm water. Others argue that there is no convincing evidence of an increase in runoff during the preceding forty years, despite the supposed increased incidence of flood disasters.

The complexity of flood processes is well recognized and only integrated approaches can sufficiently take it into account and lead to adaptive and effective flood management. An improved approach to watershed and floodplain management integrates land management in the uplands with land-use planning, engineering solutions, flood preparedness and emergency management in the lowlands.

Based on the above arguments, although it may not be appropriate to state that the direct effect of deforestation is flooding, it is important to note the detrimental impacts of deforestation to the environment and which play non-negligible roles in increasing the vulnerability of the adjacent environment and local communities.

2.10 Forests, Forest Management AND Disaster Risk Reduction — The linkages

Relationships among forests, forest management and past disasters are obtained through experiences collected from various countries around the world and derived from literature reviews.Stakeholders and decision makers can thus have an improved view of how forests and disasters are interrelated, with an aim to enrich their knowledge for a better disaster risk reduction at local, regional or national level.Moreover, ecosystem management can contribute to more effective reduction of disaster risk in two major ways. On one hand, well-managed ecosystems can mitigate the impact of most natural hazards such as landslides, hurricanes and cyclones. On the other hand, productive ecosystems, past-disaster can support sustainable income-generating activities and are important assets for people and communities.

Tsunami-related Events

Following the Indian Ocean Tsunami of 26 December 2004, which was one of the worst natural disasters in modern times, researchers as well as stakeholders in local, national governments, international communities recognize the importance of disaster risk management. Among the 10 preliminary less-ons learned from the tsunami the statement 'careful coastal land use planning is essential to minimize risk' figured. Related to this issue, various experiences from different countries are presented in this section.

In the Indian state of Tamil Nadu, villages in Pichavaram and Muthupet, having dense mangroves, seem to have been buffered from the worst effects of the tidal waves in comparison with other neighbouringing areas without mangroves. Also, Shelterbelt plantations of "Casuarina equisetifolia" along a strip of Tamil Nadu's coast were reported to be effective natural barriers; the trees were mature enough to withstand the tidal waves. Benefits from mangrove forests protection were also reported in other areas such as Ranong and Phang Nga provinces in Thailand saving hundreds of lives or in Acgh (Indonesia) where coastal areas with dense mangrove coverage experienced a relatively smooth incoming tide rather than the full impact of the tidal wave. This area registered far fewer deaths than other nearby areas where mangroves had been previously cleared. The same source acknowledges the importance of considering other factors such as bathymetry, wave energy and coastal topography that significantly determined the extent to which mangroves were able to play a positive role.

In Sri Lanka, intact coral reefs, vegetated dune systems, deep stands of mangrove forest and other natural barriers, as a first line of defense, appeared to have afforded significant protection to the coast beyond them. Also, related findings proved that reefs and mangroves were able to absorb wave energy, and that sand dunes bound by roots were much more resistant to water and wind than was bare sand. This led to the-conclusion that if Sri Lanka still possessed as many natural defenses as it did before its sand dunes and coral reefs had been mined, then the tsunami may have caused far less damage.

From these lessons, it is seen that attention should be paid to all factors that influence impacts of disasters, and at the same time to the role that forests play to withstand those disasters, regardless of other beneficial effects of factors such as protection from coral reefs, sand dunes and other coastal ecosystems.

Storm-Related Events

Following Hurricane Mitch that killed over 18,000 people and caused an estimated US$4 billion in damages, the issue regarding forest degradation and disaster vulnerability received the greatest attention in 1998. Flash floods, landslides and mudslides were the results, of this ravaging hazard. In the aftermath of Mitch, studies in Honduras, Nicaragua and Guatemala revealed that farms using agroecological practices, including agroforestry, withstood the impacts from the storm better than those using conventional farming methods. Findings in these studies showed that sustainably managed plots retained more topsoil and soil moisture, experienced less erosion and fewer economic losses than neighbouring plots.

Another example is the experience with devastating typhoon Wukong in 2000. Areas under the project with the collaboration of the Vietnam National Chapter of the Red Cross and local communities dealing with plantation and protection of mangrove forests in northern Vietnam remained unharmed, while neighbouringing provinces suffered huge loss of lives, property and livelihoods.

Landslide-related Events

Researchers are trying to link landslide-related disasters with local land use management and especially with forest management. However, more efforts need to be made. Others argue that the level of landslide hazard is not only dependent on storms and land physical attributes, human activities, especially agriculture practices, are also important considerations. It has been reported that an increase in forest cover, especially on mountain slopes, can reduce the risk of landslides and flooding associated with extreme rainfall events; and although forested areas had the lowest landslide risk, areas recently abandoned and covered with shrubs were much less affected in comparison with grass fallow, croplands or bare soil. These differences were found to be even more dramatic in areas of steep slopes.

To illustrate these facts, for example in Honduras and Nicaragua, findings showed that as slopes increased, the percentage of land affected by landslides, especially when the soils were saturated, increased sharply on land used for crop production, indicating that agricultural activity and the associated removal of deep-rooted permanent vegetation increased the landslide hazard on steep sites. Results in the same study showed that sites covered by shrub fallow and forests had relatively low incidence of landslides, regardless of the topographic features. This lead to the conclusion that the likelihood of landslides was significantly influenced by slope and land cover.

In another case, the Tokage typhoon (Typhoon No. 23) that hit the Japanese islands in 2004, leading to landslide disasters, showed evidence that, along with disaster preparedness, proper management of the environment—its air, land, water, forests, and wastes—go a long way in reducing the risks and vulnerabilities associated with typhoons. This report also highlighted the contribution of poor forest management to the vulnerability of the environment.

Unit 3 ❒ Urban Disaster Risk Management

Structure

5.1 Urban risk — an understanding

5.2 Urban Management

3.1 Urban risk — an understanding

Urban vulnerability is now accepted worldwide as a Reality. Unfortunately urban risk reduction in terms of probable disaster risks is comparatively less recognized, yet very important. One of the underlying reasons for this biased perception is based on the evidences of past disaster events, which have mainly disrupted a region comprising a few towns and more hinterland. Nonetheless, with the balancing population across rural-urban settlements, it is imperative to develop thorough understanding of risks critical to urban areas and ways to minimize not only the losses but the risks as well.

The world is steadily becoming more urban. Many consider urbanization as an irreversible process and thus urban vulnerability becomes a reality. Combinations of environmental and economic pressures, force the rural poor to search alternatives in nearby cities or towns. They habitate in informal settlements as land in urban areas, safe and developed, are very short of demand. Informal settlements mean encroachment on public and private land which thereby become slums and squatters' colonies. These are close to commercial, industrial and residential locations to enable the poor to earn. They have no choice but to settle in such locations being marginal to the developed areas, and are subject to natural or manmade hazards.

Urban risk matrix explains that urban hazards and vulnerabilities are greatly interconnected whereas there are many factors which contribute significantly as 'risk multipliers'.

The factors which make urban risk more critical than in any other built environment are :

(a) Urban population growth

(b) Growth and expansion of urban structures – the environmental impact of its growth on it adjoining areas is being continuously enlarged.

Analysis of Tokyo metropolitan region shows that its environmental footprint is much larger than that of Japan. Since both urban area and dependent rural areas are interconnected in many ways, a disaster in either of them may impact other adversely.

(c) Urban setting – many urban areas which have had seeming positive (like coastal zones, fertile volcanic slopes) setting earlier are now concentrations of multiple hazards both natural as well as man made.

(d) Compact urban forms

Urban areas with high concentrations of people even at one time a day are vulnerable to any disaster.

(e) Urban primacy

A disaster striking an urban area may not only affect the city itself but depending upon its functional primary (say if Kolkata is devastated, the whole state will be in jeopardy – as every primary activity is concentrated in Kolkata), may hamper a wide area.

(f) Urban built environment

This is important since human vulnerability to hazards depend on safety measures taken for building urban infrastructure. Moreover infrastructure damage can impair majority of the city functions and wobble the economic base of the region specially targeting at the poor. Hurricane Katrina did such a severe damage to New Orleans in USA.

Lastly urbanization itself in most cases, has proved detrimental to local and regional environment. The effects are numerous – loss of biodiversity, disruption of ecosystems, respiratory infections to the poor, adaptation of various vector borne infections to urbanization, other various physicochemical hazards including exposure to lead, airpollution, amplification of heat waves (the urban heat island), ground subsidence, surface and groundwater contaminations, water table reduction etc.

Urban management :

Urbanization, a result of complex socioeconomic process with heterogeneous societal structure, opportunist political system, lack of administrative capacities, very poor resource generation capabilities, archaic urban planning and development contributes collectively in making cities more vulnerable to poor management and disaster risks. In a developing nation, occurrences of disaster wash away their existing limited resources and leaves a huge task to further upgrade city infrastructure and services.

Urban risk reduction – recommendations Drawn entirely from "Words into Action" a guide for implementing the Hyogo Framework", UN/ISDR publication 2007, Geneva):

- Urban local governments have the primary responsibility for implementing measures to reduce disaster risk. Disaster risk reduction needs to be an essential part of a city's investment in development. In this endeavour, civil society, national and international organizations should come forward.
- Disaster risk reduction must be integrated into development activities
- A multihazard approach can improve effectiveness
- Capacity development (betterment of the ability of people through training etc.) is a key strategy for reducing disaster risk
- Decentralize responsibility for disaster risk reduction. Use GIS and RS as exhaustively as possible in the organizational approach

- Effective disaster risk reduction requires community participation irrespective of gender. Public private partnership are an important tool for disaster risk reduction. This should be a voluntary effort
- Disaster risk reduction needs to be customized to particular settings.

Note – GIS – Geographic Information System
RS – Remote Sensing

Unit 4 ❒ Rural Livelihood and Management of Disaster Risk-Reduction

Structure

4.1 Introduction

Communities of the vulnerable regions, during a natural disaster, need empowerment to do what they think best for their regions. Their decisions are usually derived from their sensitivities, developed from experience and are majority approved. thus community based approach specially in rural environment is the primary alternative for managing and reducing risks in vulnerable regions, more so when small-medium scale disasters are recurrent. Such recurrences are observed to affect people's livelihood and accelerate poverty. In rural regions only community based institutions are found to have significantly aided to sustain risk-reduction efforts in longer terms. There are certain types of natural disasters like those which are climate-related may be mitigated and prevented with sound environmental management methods.

The strategy successful when applied in Vietnam, is two prong — holistic alongwith community participatory approach. At every step, sensitivity of the area is a must for those who are leading the efforts.

During a natural disaster like floods (Climate disasters account for 80% of natural disasters in Asia), it is noted that a controlled land use, coping mechanism and diversification of income sources are most important. In this manner perhaps, damages from floods in agricultural areas can be controlled. The elements/components meant for flood mitigation can ensure adequate and safe agri production and income stabilization during the season of flood. Partnership among different Govt. Departments and civil society organizations is essential for doing it effectively. Education and training in some professional/vocational programs are significant contributors to the task and raise much hope. Professional training should be able to provide villages with some income in the season. Enhancement of community potentials may be realized. A system development process may be initiated throughout the adjacent similar blocks to enable the community to persist with their activities for a longer period.

In Vietnam, the case of Huong Van community exemplifies community based action for improving upon their livelihood concurrently with mitigation of flood effects around the river name 'BO'.

4.2 Action Pointers

1. Villagers dig out a network of canals with sluice gates and ultimate connection to the river.
2. Around existing agricultural fields, villagers excavate ponds and the recovered soil are used to raise these pond embankments. The embankments at a higher level may be used to build flood shelters through Govt. help. As soon as there is a high tide, the sluice gates are opened and as the low tide sets in sluice gates are closed. Artificial ponds act as as storage house of water.
3. Local people may develop their own economic activities using local materials and professional training, imparted.
4. Tackling issues of sanitation and energy fuel can develop cooperative biogas system.
5. Training in animal husbandry is necessary so that people can move on to different domestic animals suitable for the region. It should be borne in mind that the animals in question enable villagers to use the animal waste as fertilizers for better agri productivity.
7. Concurrently, these above wastes could work as natural pesticides.

4.3 Discussions among villagers, researchers etc.

Discussions among villagers, researchers, civil society organizations and various Vietnamese Government Departments have helped to understand the holistic systems approach to disaster risk mitigation and linkages among various activities and elements have been establishd with an eye to improving rural livelihood in Huong Van. In this effort, the systems project has categorized the following activities.

1. Co-operatives - framework & development and anointing the seed.
2. Community Resource Center
   (Relevant Disaster Management & Agricultural topics — learning)
3. Training
4. Livestock association and micro level credits
5. Biogas system development
6. Develop informations sharing system
7. Establish environmental protection club with school children, school teachers, parents association, women's union
8. Women's union have shown how to maintain livelihood coping mechanism with floods. They work as volunteers for vocational training of the denizens.

Units 5 ❐ Drought Risks Management

Structure

5.1 Definitions

Drought is a condition of lesser than normal availability of water, hence it is as much a management issue as a technical one. Drought tiggers a crisis but does not cause it. The complex interplay of climatic factors (lack of enough rainfall, uneven distribution temporally as well as spatially) and non-climatic factors (such as land situation and water management practices) results in widespread and sometimes irreversible impact on vulnerable livelihood systems. During droughts, low to very low rainfall in many parts of the concerned region and consequent depression in agricultural production as well as erosion of productive assets can result in malnutrition, migration and shifts in occupational patterns.

Drought is defined as a situation brought about by a prolonged period with less than average rainfall. Agricultural drought means that there is insufficient moisture for average crop production. Hydrological drought takes place when the water reserves available in aquifers, lakes, reservoirs (in all resources of water) etc. fall below the statistical average.

The droughts have a direct bearing on livestock and agriculture based livelihoods. The impacts have the potential to spiral into secondary and tertiary effects like poor public health, malnutrition, migration, crime and other such social manifestations.

5.2 Relief, Management and prevention

Appropriate handling of water resources in a drought prone area with the aid of traditional wisdom, modern technology and water resource management systems may take care of the difficulties faced. Risk reduction management of drought is site specific. The nomenclature 'drought proofing' is a holistic approach of securing livelihoods in a drought prone area through water harvesting and management interventions. In the Kutch districts of Gujarat, a drought proofing project through watershed development and eco-regeneration for vulnerability reduction has been set up. It aims to support and facilitate the planning and implementation of initiatives towards long term recovery and drought proofing of the region.

5.3 Drought Monitoring and Management

Drought monitoring is an important activity of the management program. Drought monitoring is directly related to rainfall and projected availability of water in an area. The associated factors like availability of groundwater, reservoir position and pest control also form part of drought monitoring. Integration of the national information system with the program is called for a better information dissemination.

Issues in Drought Management :

- Generating awareness among communities to predict, face and cope with a drought or drought like situation. Women are crucial in the awareness program.
- Strengthening community based initiatives and promoting holistic drought preparedness and mitigation plans through Panchayeti Raj Institutions. It is ensured that women participate in numbers.
- Training and capacity building of the central and state institutes and departments
- Strengthening existing administrative, legal and institutional frameworks at national and state levels for drought risk management.

Drought Mitigation (in India)

- Harvesting (including Check dams too) rainwater and water purification and storage systems for direct use and infiltration systems for recharging groundwater levels. Use of traditional knowledge may be helpful.
- Determining the principles and systems of water distribution.

Comprehensive reporting of agricultural drought has been a challenge due to its unique characteristics. In India, drought monitoring and early warning are carried out by the central and state agencies using the meteorological and agricultural data. India is also - one of the few countries which use satellite data for monitoring and assessment of agricultural drought through a program called the National Agricultural Drought Assessment and Monitoring System, (NADAMS). NADAMS uses several satellite-based reflectance and emittance indices along with meteorological and agricultural data to monitor and assess agricultural drought. Integration of satellite-derived information and ground data ground provide agricultural drought warning declaration during the cropping season in the states of Andhra Pradesh and Haryana using IRS-AWiFS/WiFS and NOAA-AVHRR data respectively.

5.4 Drought Characteristics

One of the major disasters which severely impair food production is drought. It is a normal part of the climate, rather than a departure from the normality. Drought is a complex phenomenon that can be defined from several perspectives. The definition of drought varies depending on place, time and person. Drought can broadly be defined as the water or moisture deficit at particular location, during a particular period of time and for a particular person. The location can be an arid region or a humid one. The period could be critical phase of the crop like germination or flowering and the person could be poor or rich. Hence, any accurate definition of drought will be applicable for a specific place and for a specific person during a particular time period. There are several general definitions of drought. It has been defined by the international meteorological community in general terms as a 'prolonged absence or marked deficiency of precipitation,' deficiency of precipitation that results in water shortage for some activity or for some group, or 'period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance'.

Drought differs from other natural hazards in several ways. First, it is a slow-onset natural hazard, often referred to as a 'creeping phenomenon'. A week of dry spell during the monsoon is always welcomed by most. As the dry spell extends for a fortnight or more it slowly gets transformed to what may become a drought. During this transition, none can the onset of drought unless it starts hurting them by way clearly apprehend of shortage of drinking water or lack of soil moisture for the crops or loss in power generation due to lack of water head in the reservoir.

However, its effect is over a. larger geographic area unlike the other hazards which are local and location-specific. Uncertainty exists in identifying the exact boundary of the drought affected area, as it is not discrete and there is a slow transition from the non-drought area to drought-affected area. Third, the duration of drought may range from few months to several years. The onset and end of drought period cannot be deciphered with certainty. The impact of drought is non-structural when compared to the damages that result from other natural hazards like flood, earthquakes and tropical storms. All these characteristics, make droughts particularly challenging to quantify and provide relief as compared to other natural hazards. Drought affects virtually all regions of the world. It is a misconception that it does not affect the humid regions. In 2006, the Indian state of Assam which received which over 1500 mm during four months (June-September) of southwest monsoon," faced drought for a brief period. This emphasizes that almost any part the world can be vulnerable to drought.

5.5 Types of Drought

The basic reason for manifestation of drought in any region is the precipitation. In the hydrological cycle, rainwater gets transformed to become run off water seepage water etc. Any substantial shortfall of water at each transformation causes hydrological imbalance which will lead to a particular type of drought. Broadly, three types of drought are noted: meteorological, agricultural and hydrological. Meteorological drought is generally defined as deficiency of precipitation from the expected or 'normal' amount of rainfall during a particular period of time. Meteorological drought precedes all the other types. Agricultural drought may be characterized by a deficiency in soil water availability for crop growth. The precipitation deficiencies may lead to reduction in the soil water reserves which may affect the production potential of the crops. Hydrological drought may be a result of long-term meteorological droughts which result in the drying up of reservoirs, lakes, streams and rivers, and consequent fall in groundwater level.

Agricultural drought is the most complex among the three types. While dealing with agricultural drought, we consider rain-fed agriculture since irrigated agriculture has a definite source of water, apart from rainfall. With meteorological and hydrological drought, the deviation from normal can be categorized into different degrees of drought. However, such simple deviation measures are not possible with agriculture drought as it involves many physical and biological processes. It is the water imbalance between the demand and supply in the soil-vegetation-atmosphere continuum which matters. Further, the water imbalance can happen at any stage of the cropping season. Based on the period at which the water stress happens (during the cropping season), agricultural drought can be classified into three categories, namely, early season, midseason and late season or terminal drought. We also encounter two more types of drought.

Early season drought: Under rain-fed conditions, the cropping season commences with the significant first soaking rainfall. In India, sowing starts with the onset of monsoon during June. If there is delay in the onset of monsoon, sowing is also delayed. It is also possible that onset is timely and sowing is completed but followed by a long dry spell. Germination and the period just after are among the critical phases of the crop and dry spell leading to moisture stress which will lead to crop mortality and loss of net sown area. Unless and until these gaps are filled, there will be reduction in crop production. The loss of crop yield due to the early season moisture stress is called the early season drought.

Mid-season drought: When the crop in its vegetative phase experiences moisture stress due to break in monsoon or due to a long dry spell, it is called a midseason drought. Generally, when the crop is well-established and then undergoes such midseason drought, it becomes stunted but survives. Once the monsoon revives, the crop may partially or completely recover depending upon the persistence and intensity of dry spell. The loss in crop yield due to midseason drought varies.

Late season or terminal drought: The flowering and milking stages of the crop are very critical phases. If there is moisture stress during this phase due to lack of rainfall, it will lead to loss of yield both in quantity and quality. The loss of crop yield due to moisture stress during the reproductive phases of the crop is called the late season drought.

Apparent drought: The rainfall during a particular period of time may be sufficient for one crop but it may not be adequate for another crop. The stress may also be induced by the type of soil on which the crop grows. The same amount of rainfall for similar crops at the same stage, on sandy and loamy soil will result in the former crop getting stressed early than the latter. This sort of differential stress to crops for the same amount of rainfall is called apparent drought.

Permanent drought: When the monsoon fails in its quantity and distribution temporally as well as spatially, complete failure of crops occur at a regional scale. Such scenarios often happen in the arid and semi-arid climatic regions where the rainfall has very high variance.

5.6 Prediction of Agricultural Drought

Though the main cause for agricultural drought is the deficiency of rainfall, it is the anomaly in atmospheric circulation which is responsible for deficit rainfall. Hence, in order to predict drought, it is important to monitor the atmospheric and ocean circulations. Enormous energy exchange takes place between the ocean and the atmosphere which has a lasting effect globally on a timescale of a few years. One such phenomenon is the Southern Oscillation (SO), an atmospheric component and associated El Nino, an oceanic component, jointly called the El Nino and Southern Oscillation (ENSO) which has a profound impact on the performance of global tropical monsoons. 'Strongest connection between ENSO and intense drought can be found in Australia, Indonesia, Philippines, parts of east and south Africa and Western Pacific Basin island, India, Central America and various parts of United States'. ENSO weakens the summer monsoon and is related to drought occurrence in India. During the period 1971 to 1988,11 of the 21 droughts were attributed to ENSO phenomenon. About 58% of the drought events in India were associated with ENSO phenomenon.

Apart from monitoring the teleconnection phenomenon like the ENSO, analysis of long-term climatic records may reveal persistent trends or definite cycles of drought. Region-based empirical models can be developed in order to predict the possibility of occurrence of drought. An analysis of the long-term rainfall data of 77 semi-arid locations of India attempted to derive rainfall probabilities to quantify rainfall in agronomically relevant terms.

IMD uses indigenously developed statistical model with six predictors to forecast the monsoon onset over Kerala since 2005. These predictors are: Northwest India Minimum Temperature, Pre-monsoon rainfall peak over south Peninsula, Outgoing Long wave Radiation (OLR) anomaly over the Indo-china region, South Indian Ocean Sea Surface Temperature, South Indian Ocean lower tropospheric wind and Outgoing Long wave radiation (OLR) anomaly over Southwest Pacific region. The statistical model has a forecast error of ± 3 days. The other major regional predictors of the Indian summer monsoon could be (i) Premonsoon surface pressure and thermal fields over India, (ii) Pre-monsoon 500 hPa ridge location over India, (iii) Upper ropospheric winds over India and (iv) ENSO indicators.

Advances in knowledge, combined with an expanded range of data and computing power, have helped to develop prediction schemes based on computer models that holistically represent the entire earth/ocean/atmosphere system. However, a survey of the scientific literature, and experience, reveal that a variety of impediments obstructs the optimal use of seasonal climate forecast, especially in drought mitigation. It is a challenge even today to predict drought a month or more in advance for most locations as this mainly depends on the ability to forecast two basic parameters viz., precipitation and temperature. The anomalies in precipitation and temperature may last from several months to years.

5.7 Conclusions

Drought is a progressive subtle disaster which affects large population because of the aerial extent unlike other natural disasters. It damages the environment and livelihood of the people. Because of the unique nature of drought, development of drought monitoring and early warning system has been a challenge. Due to global warming and changing climate, the frequency and intensity of, drought have also been ever increasing. This has made the world population especially in the developing countries more vulnerable to drought. With the availability of huge amount of ground-based meteorological and agricultural data, and several drought indices both from ground and outer space platform, many initiatives around the globe have been tracking drought. In India, the NADAMS program has been monitoring and assessing agricultural drought. Capability of satellite-derived indices along with the ground data to provide more objective information temporally and spatially have been clearly demonstrated. Several other international and national endeavors are in place to monitor and assess agricultural drought. There is a further need for a concerted effort by the world community to improve existing drought monitoring and early warning system. It is also important to make the information readily available to the stakeholders so that proactive measures can be taken to manage drought and mitigate the adverse impact of drought on the national economy and welfare of the human beings.

National Drought Policy

Drought management is a priority for the GoI and the Ministry of Agriculture (MoA) is the nodal agency for policy implementation. The emphasis earlier on drought management was on large scale drought interventions for the prevention of physical and social-economic deterioration. It hinges on guaranteeing the vulnerable families a normal life in the drought period. Recurrence of droughts has triggered a series of discussions on the right approach to tackle the problem and on how communities could be better prepared in dealing with poor or no rain situation (the latter is known to change the soil moisture level, critical for crop production.

Activities undertaken for short term measures have mainly been focussing on providing drinking water, fodder for livestock, distribution of food grains and provisions for gainful employment for the affected people. Entrancing the scope for better irrigation support to crops and for developing new water sources are also included. This is not cost effective and does not promote community participation. In order to minimize increased use of resources for relief operations, the Govt. of India is keen to develop a long term strategy. GoI is therefore strengthening the preparedness mechanism, at the same time ensure that factors such as climate variability soil conditons and environmental degradation are considered.

Drought-Prone Area Programme and Desert Development Programme are among the several area development initiatives undertaken in select districts identified on the basis of 'moisture index' and 'percentage area under assured irrigation'. The 'Haryali' programme is the first step, launched to promote the integrated development of water sheds in the country. The former watershed development policy has been modified to make it contemporary, transparent and easy to follow. It provides a greater degree of flexibility in view of the large variations in local conditions, needs and the social structure. The Guidelines for Watershed Development (2001) have been reformulated to ensure :

(a) programme specific and focussed project approach
(b) greater flexibility in implementation
(c) well defined role for state, district and village level institution
(d) removal of overlaps
(e) provision for keeping the watershed development projects on probation
(f) an 'Exit Protocol'
(g) a 'turn-track' approach to the implementation of projects
(h) seeking a combination of GO/NGO action
(i) greater role for women
(j) effective role of the PRIs

(k) highlighting self help groups comprising rural poor, more so if they belong to disadvantaged categories
(l) establishing a credit facility for financial institutions
(m) transparency in implementation
(n) effective use of remote-sensing data

In the context of drought, the above policy does not address the link between climate and weather variations that are crucial in determining the moisture level and crop production. Though the policy identifies an 'exit strategy', there is a need to ensure that the coping mechanisms, through structured drought proofing plans (adopted by the communities) rely on climate and weather factors that are linked to a larger system beyond the village.

Drought Mitigation Management — Case Histories

Two kinds of approaches are available for reduction of the impact of drought on agricultural communities. The first is the long term planning and precautions taken to reduce impact. The second pointer is the action taken during the onset of the event to reduce the adverse effects on agriculture.

In India efforts are made to stabilize the dry land agriculture by developing contingent crops production strategies in the rain-fed areas. Drought management policies contain agricultural planning and practices with consideration of overall water requirement within the individual agro-climatic zones.

In case of an incidence of drought in the growing season, appropriate crop management strategies are to be adopted. These strategies may vary from moisture conservation to operation of plant population and fertilization. Rainfall can also be harvested in farm ponds and village tanks and remaining water may be used for irrigation. Crop planning can be thought of to avoid crop competition for available moisture. In case of a long break in rainfall, supplemental irrigation may be provided.

India has a network of rainfall stations who can be drought watchers. For drought mitigation the regions should diversify into agro industry or various other products which can create new directions of income. Improvement in agri-technology, development of water resource and animal husbandry should be initiated locally while the govt. may start reduction of land revenue, distribution of food, food for work progress during emergencies.

The drought watch centres should distribute information to the farmers concerned.

In a post drought situation, govt. should organize distribution of some contingency plan supply seed and fertilizer free.

Information is usually provided to farmers through agricultural extension services. Farmers are thus now better trained and they respond with confidence. In monthly drought monitoring activities, the water stress plotted on a map each week indicates parts under distress. Agroclimatic zoning supports planning and policy formulations. There is a long tradition as at some dry places in Maharashtra of water tank construction for water harvesting. The purpose is to store water for agricultural need when necessary.

Adaptation Options in USA

Recent studies by the National Research Council (NRC) and other organizations have emphasized the ability of American farmers to adapt to the changing conditions. The US has substantial agricultural research capabilities and a wide range of adaptation options which are currently available to farmers. Hence, as far as the US is concerned agricultural adaptation to climate change appears favourable, assuming that water is available. Other countries, particularly in the tropics and semitropics, are not so well provisioned with respect to both the research base and the availability of investment capital. Present agricultural institutions and policies in the US tend to discourage farm management adaptation strategies, such as altering the mix of crops that are grown. At the policy level, obstacles to change are created by supporting prices of crops that are not well-suited to a changing climate, by providing disaster payments when crops fail, and by restricting competition through import quotas. Programs could be modified to expand the flexibility allowed in crop mixes, to remove institutional barriers to the development of water markets, and to improve the basis for crop disaster payments.

Focus on Sri Lanka

Further investigation of the available information on the effects of meteorological disasters on Third World agriculture is necessary. The existing effects show the lack of agricultural self-sufficiency in a large number of low-income countries and the, consequent hunger and poverty. Some agricultural planning mechanisms in hydrometeorological disaster-prone developing countries, to mitigate the adverse effects of such disasters are discussed here. It is necessary to mention that the mechanisms should be linked to national development planning in these countries.

The Department of Meteorology provides forecasts of weather and climate parameters using data from 20 synoptic stations with daily 3-hourly observations of pressure, temperature, humidity, wind, visibility and clouds transmitted to the National Meteorological Centre in Colombo by telephone. Data is collected through the upper air observation system, with radar wind observations and radio observations. Pilot balloon observations are made thrice a day when radar wind observations are not possible due to malfunction of the obsolete system. Thirty-three agrometeorological stations transmit data from over

400 rainfall monitoring stations maintained in collaboration with governmental and non-governmental institutions, and voluntary observers. Daily observations from other 70 stations are transmitted by telephone for weather forecasting; the rest by post every month. The National Meteorological Centre in Colombo operates on a 24 x 7 basis. Recipients of information are the farmers, fishermen (for the Fisherfolk Radio Program), energy, aviation, and shipping sectors, the mass media and the general public. Weekly rainfall and cumulative rainfall for the Yala and Maha seasons (main rainfall seasons) are sent to FAO office in Colombo. Hazards monitored include heavy rainfall events, thunderstorms, tropical cyclones, and drought. Compared to cyclonic storms, which are infrequent yet severe, thunderstorms and heavy rainfall episodes are high-frequency, low-intensity hazards that have significant cumulative impact. Forecast information of actionable lead time can reduce risks to these hazards.

Specifically, the following limitations, as identified by the Meteorology Department, exist: synoptic stations are still manually operated (manual recording and coded data transmission by telephone), Inadequate number of observation stations, observation capacity to verify forecasts from regional/ global centres (e.g., India National Centre for Medium-range Weather Forecasting) are inadequate, upper air observation instruments are obsolete, hence unreliable; there is an absence of meteorological surveillance radar system for tracking bad weather patches, high reliance on telephones for data transmission exist, back-up communication system during emergency is non-existent, most rainfall stations still transmit data by post (monthly), GTS connection with WMO is bare minimum (capacity is low—50 baud speed, hence unable to receive increased data flow, such as tsunami information and numerical weather and climate prediction capability is not sufficient).

The following measures are recommended by the Department of Meteorology to address these constraints: upgrading of 20 synoptic stations (to become automatic/ telemetered) and upper air observation system, installation of additional observation stations (meteorological surveillance radar system, 15 automatic weather stations, rain and stream gauges in upper catchments areas, replacement of radio system, establishment of more reliable and efficient data communication system, upgrading of the GTS using TCP/IP link, capacity enhancement of data processing centres (computing facilities, including automatic weather chart plotting system, numerical weather receiving system), capacity building on numerical weather and climate prediction, capacity building on generating forecasts of various time scales, suggested locations of automatic weather stations, where capabilities need to be developed within the Department to make them usable for emergency planning, flood management, contingency crop planning, and water resource management. Department of Meteorology could have the capacity to generate seasonal forecasts. However, capacity to deliver localized forecasts that meet end-user needs (e.g., to guide cropping decisions) is a major constraint. Capacities for the generation and application of localized seasonal climate forecasts may be built within the Department. The International Research Institute for Climate Prediction (IRI) has already undertaken a preliminary downscaling of global climate model seasonal precipitation forecast for Sri Lanka. ADPC has an existing partnership with IRI in the generation and application of downscaled seasonal climate information in agriculture and water resource management in the region (particularly Indonesia, the Philippines and Vietnam. Sri Lanka can draw from this experience). In the Philippines, an institutional mechanism is in place involving the meteorological, agriculture and water resource agencies from the national, subnational and local levels, the local government and end users. A systematic drought monitoring mechanism in Sri Lanka may be developed and institutionalized, with the participation of various institutions who are directly concerned with crop-weather relationships. A crop-weather watch group may be constituted, to meet regularly during the year before the start of the cropping season until the season is over, to monitor meteorological, hydrological, and agricultural and market indicators.

The Department of Meteorology should report weekly summary of observed daily rainfall values from its rainfall monitoring stations, with respect to each meteorological zone with rainfall forecast. With this input, the crop-weather watch group is able to detect late onset of the monsoon, long dry spells, abrupt break in monsoon conditions and early withdrawal of the monsoon. The Irrigation Department should report weekly observed river levels in the major rivers and reservoir sites, keeping in view the corresponding average water level in the last 10 years. This report, along with the information on water availability in small reservoirs and minor irrigation tanks from the Agrarian Services Department, surface water flow details from the Irrigation Department, and observed rainfall values from the Meteorological Department, would give a scenario on the soil moisture deficit with respect to various cropping zones. The agricultural inputs specialist and the extension specialist shall provide a-weekly report to the group on the progress of agricultural operations, such as nursery preparation, seedling conditions/sowing preparations, transplantation, crop growth and crop condition with respect to paddy and other major crops. Any abnormal demand and supply of agricultural inputs will be construed as a sign of deviation, and thorough examination would be made bv deploying rapid assessment teams to the areas. Warning of floods (riverine and dam breach/ release of stored water) is the responsibility of the Irrigation Department, which has been successfully operating the flood warning system for Colombo in the past 20 years. The flood warning system provides 12 hours lead time for Colombo. Out of 123 river basins, 11 have been identified as critically flood-prone. Surveys are now underway to establish flood forecasting systems in 5 of these critically flood-prone basins.

Role of the FAO

As an international organization, FAO plays an important role in disaster prevention, mitigation and preparedness and rehabilitation work around the world. To reduce the vulnerability of agricultural systems to disasters, FAO provides technical assistance to its member nations to prevent or mitigate the impact of meteorological disasters such as windstorms, hurricanes, cyclones, floods, frost and other related disasters. Technical assistance includes, establishment of shelter belt, plantations, forestation and forest management, watershed management, control of soil erosion, crop diversification, construction of drainage and flood control systems. Use of participatory approaches, allows people living in vulnerable areas to express their needs and concerns with recognition of disaster mitigation at risk level. FAO supports to build up Rapid Agricultural Disaster Assessment, moving affected persons to safety, mobilizing and distributing emergency food and other humanitarian relief in the disaster situation. It mobilizes international support through Global Early Warning and Information System. It provides early warning and crop and food supply assessments before and during emergencies. It also provides agricultural inputs and other support to rehabilitate and restore the agricultural production systems. FAO also provides assistance to develop disaster prevention programs and preparedness plans for weather-related disasters on agriculture.

Farmers' Adaptation to Climate Chance on Agriculture

A wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on agriculture at the level of farms. These are, the introduction of late-maturing crop varieties or species, switching cropping sequences, early sowing, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods, and improving irrigation efficiency. Agricultural improvements have always depended upon the investment in agricultural research and infrastructure. It would help to identify through research, the specific ways that farmers adapt to the variations in climate. Farmers attempt to manage for a less favourable climate by applying more fertilizers, more machinery or more labour. Success in adapting to possible future climate change will depend on a better definition of the changes that will occur at various locations and on practical investments, in timely adaptation strategies.

Recommentations

Issues and impact assessment, mitigation, adaptation and preparedness strategies of disasters and extreme weather events on agricultural activities have been discussed. The impact assessment of climate disasters can be extended from agriculture to social and economy, local to regional and national and global level. It can be concluded that with increasing incidence of climatic disasters around the world, a comprehensive assessment of their impacts on agriculture, forestry, and fisheries and strategies for mitigation of those disasters is critical for sustainable development, especially in the developing countries. These disasters are.affected by the modes of climate change, climate variability and their extreme events, therefore, the strategies for adaptation and preparedness are required for these modes. This will have extremely profound implications for meteorologists, natural resource managers, hydrologists and agriculturalists as they attempt to adapt to and mitigate the effects of such disasters on agricultural activities. Advanced research and information sharing of higher level institutions on application of mitigation strategies could minimize damage in the areas of agriculture, forestry and fisheries. Increased involvement and personal responsibility at the community and sector level, based on knowledge of the hazard, recognition of its likely occurrence, and knowledge of appropriate strategies could also help to reduce the risk. The following recommendations can also be suggested:

- A national sector-wise complete database is required to evaluate the impact of disasters on agriculture. It is necessary to assimilate data management system with adequate collection and analysis with presentation of data specific to certain kinds of climatic disasters, for example, lightning incidence, wind damage, flood and drought damage with the use of available technology, viz., GIS and Internet. Effective management and preparedness for weather-related disasters requires free access to relevant databases that will allow monitoring, assessment, and prediction.
- A number of modern tools and methodologies for the monitoring and prediction of climatic disaster are now available. Agricultural risk zoning is an essential component of this type of disaster mitigation and preparedness strategies. Databases, GIS and RS should be employed to facilitate strategic and tactical applications at the farm policy levels.
- There is an urgent need for a more risk-based management approach to meteorological disaster planning in agriculture. An effective risk management approach would include a timely and user-oriented early warning system with rapid distribution of information to users.
- The concept of the drought monitor map product can be promoted as a tool for all drought-prone countries. The feasibility of organizing joint training workshops on national and regional drought monitor program under the WMO and the NDMC is essential.
- There is an urgent need to assess the forecasting skills for climatic disasters, given the importance of storms and storm surges to coastal lowlands. It is also essential that WMO, in collaboration with other international and regional agencies should develop an integrated coastal management approach in reducing such disasters in agriculture, forestry, and fisheries.
- The growing frequency of natural disasters requires effective use of the media to better inform and educate the general public and policymakers about the potential impacts of meteorological disaster on agriculture and the need to adopt preparedness strategies.

- The WMO technical guidance of impacts of such disasters on agriculture should emphasize early warning, monitoring, and prediction techniques, vulnerability and impact assessment tools, as well as preparedness and mitigation strategies. Case studies of some countries should be included. The publication could be made accessible on Internet to the public.
- It is also essential to include measurements of related weather parameters in the standard meteorological stations. There is a need and opportunity for agro-meteorologists to supply design requirements for new satellite sensors.

Policies should be documented from the experiences of countries such as Australia, China, India, and the USA.

Unit 6 ❒ Interrelationship between Disasters & Development (Also refer to Appendix-I)

Factors that affect vulnerabilities can be expressed by the following diagram : which elucidates interaction of exposure to hazards with income and capability vulnerability and risk.

In fact risk (R) = $\frac{\text{H (Hazard intensity of the disaster) x V (Vulnerability) x E (Exposure)}}{\text{coping capability (c)}}$ i.e. $R = \frac{H \times V \times E}{C}$ . . . Eq. (1)

Vulnerability is the key element which if calculated leads to the manitude of suffering. The losses that are reported in the context of a disaster fail to adequately capture the true impact of the impact of the disaster on the poor. The poor actually bear the greatest cost in terms of Lives (livelihoods), and rebuilding lives.

The impact of disasters on poverty is interlocked with other forms of human deprivation.

Let us now try to evolve the relationship of factors given in Eq (1) and evaluate how vulnerability is developed in human systems. The degree of vulnerability leads to differential impacts affecting the society.

(a) Hazard index measures the average impact of different hazard types occurring in a region from a historical perspective.

It can be represented as

$$H^k_{it} = (probability^k_{it} \text{ x } intensity^k_{it})$$

where k = a hazard type like earthquake, flood, etc drought etc.

t = time involved account of

(b) Exposure Index

$$E^k_{nt} = \frac{Population^k_{nt}}{LA_{nt}}$$

where $population^k_{nt}$ refers to the population in the region n on a time t, exposed to the type of hazard k

LA_{nt} = total land area of the exposed population in the region n and at a time t

If provincial data or state data are available then E^k_{it} in a country *'c'* can be computed additively :

$$E^k_{it} = \sum_{n=1}^{s} Population^k_{nt} / LA_{nt}$$

To determine the regions which are exposed to disaster/hazard, a historical analysis of these communities ravaged by natural disasters is helpful.

Thus the produce

H_{it} x E_{it} measures the total number of persons exposed to the disaster.

(c) Poverty-Vulnerability Index

Vulnerability is defined as the degree or (extent to which a system (Human) in a particular exposure to hazard is likely to experience harm vulnerability is often related to poverty. It has to be noted that not all poor people are vulnerable and not all non-poor people are invulnerable to the disaster. (For example, recently unemployed and poor persons who have attained a high level of schooling can possess the mental capacity to fend for themselves against disasters in contrast to wealthy individuals who have not prepared for any such eventuality).

Poverty index refers to the combination of various types of incapability and deprivation indices such as income, health, employment, education which together constitute capability and income poverty. In such indices, the effect of these above factors on disaster risk can be measured followed by a calculation of the human losses arising from disasters.

(c)(s) Capability deprivation index measures a portion of the instrumental factors between disasters and poverty within a given region. The extent of involment of these factors in the region determines the degree of exposure to disasters and the impacts. A lower level of these factors will indicate lower resilience to disasters and greater exposure to the latter. Such situations give rise to differential impacts of disasters.

The capability deprivation for each region is measured in terms of the proportion of households that are deprived of development assets. This factor, called *'C'* can be defined by the built-in environment, demographies, household development assets, human capital, environmental and social factors of a given region. One example of *'C'* is sanitation and health, access to markets, basic education and quality of education and employment.

Capability and deprivation indices $P_n(C)$ can be computed for each category of deprivation in each region *n*. Thus

$$P_{nt}(C) = \sum_{C=1}^{s} BC$$

$$\left(\frac{\textit{number of people in Category C, in region 'n'}}{\textit{number of people in region 'n'}}\right)$$

where n = region affected by disaster

C = for deprivation categories in physical, human, social and environmental capital

r = number of types of C

B_c = weights to be assigned to each of the deprivation categories based on studies on the impact of each of these variables on poverty. The regions affected are those regions that experienced a specific form of disaster in a given year.

$P_n(C)$ defines the percentage (or protability) of being deprived in regions in the total categories C. These measures can be computed across multiple regions to estimate an average national exposure level, $P_c(C)$ as

$$P_{it}(C) = \sum_{n=1}^{r} \delta_n P_{nt}(C_t), \sum_{n=1}^{r} \delta_n = 1$$

Where δ_n refers to the weights assigned to the regions in country *'i'*, based on the corresponding population.

Capability vulberability is a long term vulnerability indicator of disasters. It reflects the initial conditions affecting poverty. It is supposed to capture the ability of the community in a disaster prone region to respond to current disasters. The relevant index for capability vulnerability in the current year *'t'* will be

$$P_{it}(C) = P_{i,\,t-1}(C) + \Delta P_{it}(C)$$

Where $\Delta P_{it}(C)$ is the marginal change in the index during the current year *'t'* and $P_{i,t-1}$ *(C) is* the deprivation level before the disaster. If there is a long term development program, which is implementationally inclusive and it helps poverty reduction then the level of vulnerability faced by the specific region/country can be lessened/diminished to the previous year. Moreover, the marginal change in the current year, $\Delta P_{it}(C)$, may partly be influenced by the disaster and/or disaster mitigation measures themselves only if initiated inclusive developmental programs that improved or reduced its resilience to disaster. This could perhaps be best done if we give differential weightage to the existing level of capability (mental and physical) of the denizens in the specific locale. And we develop a score card both present and past to evaluate the progress of change. That capability deprivation and income vulnerability are not independent of each other can be understand from the following example. *The high number of educated people who are unemployed may have incomes and savings temporarily below the poverty threshold,* *but because they possess skills and job experience, they are not totally vulnerable to disasters.* This shows that governments in poor countries should implement poverty reduction programs that focus on improving capabilities rather than incomes.

It is now the stage that we try to define income vulberability. Income vulnerability is interpreted as a probability (or percentage) that the household (family) will experience a condition poverty as a result of a disaster. The probability that a region experiences poverty is thus determined by the number of people already earning below the poverty line (PL).

We then propose the poverty incidence, $V_{nt}\,(Y_{nt} < PL_{nt})$ in the region *'n'* at time *S*.

$$V_{nt}\,(Y_{nt} < PL_{nt}) \ := \frac{\text{nos of people with income below PL in region}}{\text{nos of people in region } `n'}$$

where $(Y_{nt} < PL_{nt})$

presents the probability of lower than PL (poverty level of the region).

It should be noted that PL should be varied according to region and time. If there are *S* exposed regions income vulnerability V_{it} can be computed as the weightage average of the incidence of poverty of these regions after converting households to population :

$$V_{it}(C) = \sum_{n=1}^{r} popu_{nt}\ V_{nt} \,/ \sum_{n=1}^{r}\ popn_{nt}$$

In this case too, we consider the poverty incidence of the previous year as the measure for the income vulnerability in the current year.

$$\begin{aligned} &V_{it}\,(Y_{it,}\,Y_{i,t-1},\ PL_{i},\ PL_{i,\,ti}) \\ &=\ V_{i,ti}\,(Y_{i,\ t-1},\ PL_{i,\ t-1}) \\ &\quad + \Delta\, V_{it}\,(Y_{it},\ PL_{it}) \end{aligned}$$

Where $\Delta\, V_{it}\,(Y_{it},\ PL_{it})$ is the marginal change in the index during the current year, *t*.

Using the deprivation index defined earlier, the term *'P^{t}_{i}, V^{t}_{i}'* is the combined poverty vulnerability index that shows percentage of poor people in the exposed area without capabilities.

The disaster impact index denotes the proportion of people actually affected by the disaster where vulnerability of households is already ingrained. If the size of the affected area is wider, more poor people are affected.

Combined disaster vulnerability risk index *'R^{k}_{it}'* defined as the total human impact of a disaster *'k'* in a country *'i'*.

$$R^{k}_{it} = [H^{k}_{it} \times E^{k}_{it} \times P_{it-1}\,(C) \times V_{i}\,(Y_{it-1},\ PL_{t-1})]d^{k}_{it}$$

The product

$$H^k_{it} \times E^k_{it} \times P^k_{it}(C) \; x \; V_i \,(Y_{it}, \;\; PL_{t-1})$$

is the expected number of poor/vulnerable persons (per land area) at risk before disasters in a given year.

The combined score R^k_{it} measures the number of poor persons per land area at risk for both poverty and disasters. A higher R_i implies a greater likelihood of poverty/vulnerability to persist, due to a higher convergence of disasters in the current year.

Of the various impacts that a disaster can make, physical and financial costs constitute the direct cost to the country while concomittantly they indicate the indirect costs (of disasters) to the vulnerables.

It can be written as

$$PFC^k_{it} = E_k \sum_{F=1}^{z} \lambda_F$$

where

F = physical & financial costs due to disaster *'k'* × land area *'(LA)'*; *'F'* is a specific category of the above costs set off by disaster *'k'*

z = nos of *'F'*

λ_F= λ_{FS} refer to a defined weight to each category F to physical and financial losses. These weights will express the presumed impacts of these losses on vulnerability (Poverty).

For instance, agricultural and infrastructural losses have a significant effect on the poor, hence the full weight of these losses should be taken into account during calculation. On the other hand, private and commercial losses are not fully affecting the poor, hence their weight should be minimal.

For example as floods and droughts affect more poor and vulnerable people as they become wider, the weightage should be $^2/_3$ for flood and droughts for vulnerable population, ½ for typhoon and $^1/_3$ for earthquakes.

The total disaster-vulnerability (Poverty) cost is thus the sum of the human costs value *HL* and physical financial losses *PFL* :

$$\text{Total cost i.e. } TC^k_{it} = HC^k_{it} + PFC^k_{it}$$

The total cost estimates the impact (in monetary terms) of varied forms of disaster on the welfare of the poor/vulnerable. It calculates how much the vulnerable has lost in economic terms because of the disaster. It also represents a major portion of govt expenses to bring the vulnerable/poor to pre disaster level of welfare. It indicates the magnitude of set back in the poverty-reduction program.

Increasing TC_{it} over time will indicate worsening of poverty i.e. vulnerability in the face of disasters using such a measure i.e. TC_{it}, policies can be prioritized for the mitigation of vulnerability/poverty and disaster.

Disasters have differential impacts — Physical and social and can create emergencies.

The impact of environmental degradation however causes disasters while the impacts of disasters have far reaching effects on environment, hence on development typhoon 23 produced 48000 tons of waste products in Toyo-oka city of Hyogo Prefecture in Japan, which amounts to one and half years' waste production of the city. It not only posed a threat to the city's waste management system, it had far reaching implications on the development of the city to its original state, hence on its economy and its natural environment. Disaster just can not happen. Often theyresult from failures in development (Fig.5.3). As a result, disaster increases vulnerability.

Disaster have a direct influence on economic development. In Vietnam, disasters nullified many of the development achievements. During 1996-2000 disasters caused damage and loss of about US$2.3 billion, killed on average (per year) 2117 people. Disaster dislocated families forcing them to migrate elsewhere. Natural disasters intensify the poverty gaps of the population and increase the speed of the rate of setting in of poverty. Poverty and vulnerability in the context of disaster are interlinked (Fig. 5.2) and mutually reinforcing the poor are forced to exploit natural (Environmental) resources for survival, thereby increasing both the risk and exposure to disasters, specially those triggered by floods, drought, landslides.

Deforestation and agriculture on marginal lands or felling of trees in the forest for flirewood are abetted by poverty. These practices affect the natural environment and may hurt the very resource base that the concerned poor people depend on.

Thus the rural communities who thrive on resource (natural) based activities are the worst sufferers of disaster. Livelihood management plans are necessary for providing security to this section of population. Effective plans for combating the impacts of natural hazards on the livelihoods of low-income communities need to be crafted. In this process concerns of precautionary measures like insurance in the recovery process should not be undermined.

Land use changes and haphazard development are undermining our ability to cope with the natural disasters. Natural coastal vegetation such as mangrove, sand dunes serves as green defence structures and protects coastal population and property with a bio-shielding effect. This was evident during asian tsunami in Dec. 2004. The impact of tsunami was less intense on coastal population that was protected by sand dunes or mangroves. Mangroves are very effective at dissipating wave energy and reducing flow velocity. The mangrove in Pitchavaran and Muthupet in Tamil Nadu in India acted like a shield and tsunami impact was reduced. Thus mangrove regeneration programs need to be incorporated in coastal states alongwith wetland andwatershed protection plans. Proper land use planning is required for locating people and infrastructure in disaster prone areas. This necessitates preparation of coastal zone land use planning maps with designated vulnerable zones and identification of evacuation sites alterations in the land cover modify the concentration of atmospheric constituents. The climate system responds to the human driven land cover change. This is because of the variation in the absorption and reflected solar radiation on account of land cover changes. Such effects are important at least for local and regional climatic scenarios.

Global warming i.e. increased temperature associated with perceptible climate change are expected to increase incidences of vector-borne diseases. Secondly changes in food produce due to climate change are likely to affect nutrition and health of the poor in most regions of the world. Climate change is thus predicted to increase the number of undernourished people in the developing world, more so in the tropics.

Experience shows that in deforested river catchment areas or where wetlands have been totally drained in river catchment, different hydrological regimes are created. Pattern of rainfall and its timings are affected in such a situation, more so, when climate change is synchronous. Rainfall as a result may become more erratic and flood prediction will be extremely difficult. Thus vulnerability of people to disaster increases.

Many mangrove swamps and coastal forests are under very severe threat from various river basin development activities and flood management projects. Flood prevention projects disturb the river flow vatriability and can cause severe deteriorations of coastal ecosystems. The result is that sustainable development is affected. Post-disaster assessment of hurricanes and typhoons have shown that alongwith disaster preparedness, environment management i.e. management or air, land, water, forests, wastes etc. go a long way in reducing the risks and vulnerabilities associated with typhoons. Environmental degradation supported and often originated human activities, is at the core of numerous catastrophes such as flooding, desertification, fires as well as technological disasters etc. changing unsustainable patterns of consumption and production, climate change, desertification, droughts, deforestation, industrial development, natural resource management, waste management, water conservation and management and last but not the least urban development all in fact are the most vital elements of disaster management vis a vis vulnerability and development.

It should be borne in mind that development and disaster will not converge if the elements of economic development are adapted to the local ecosystemic milieu.

Huge dams that have been built across India for the development of the different regions have not yielded the desired results. They have after some years of construction ceased as major water supplier for agriculture. Damodar Valley Project and the dam on Mahanadi in Orissa are typical examples. Secondly floods each year increased in intensity after the dams were built. Huge dams in India at least have led to disasters displacing a much wider spectrum of poor and vulnerable population. In USA therefore, huge dams have been dismantled and for agriculture narrow canals built — taking advantage of high and low tide without disturbing the natural flow of the rivers.

The problem of the dams centres around their support structures obstructing the natural flow of the river. The Nile in Egypt is an example. Different countries along the Nile have constructed various dams on the river for water and energy in the name of deveopment. The result is that the Nile is inching towards death. Thus dams in fact reverse developments and tend to produce disasters. In 1993, the Mississipi River, USA had severe floods along its course. For several decades prior to flooding, the engineers built a series of barriers/embankments to protect many riverfront communities from flood and they were considered to be the solution to the local flood problems. The barriers however also served to change the course of the Mississipi river in many areas. It is now believed that these levees and the decision decades ago to build them, in fact, exacerbated downstream flooding that adversely affected many river front communities. The apparently simple decisions to help various riverfront populations from disastrous floods led to a tangled web of cause and effect that over time brought disaster to other communities. It shows that construction of barriers/embankments is not enough; they have to be checked and monitorted from time to time for their structural and locational relationships with the characteristics of the river which has an inherent non linear behavior. The lesson is that in an uncertain non linear system (in nature), a decision taken today may not be valid in future in terms of its quality. The situation then can explode into a real disaster as it happened in the Mississipi basin. It is imperative therefore it is necessary to develop the disaster management systems based on instability and variations. It must be kept in mind that disasters are not simple straight lines, extensions of a fire. They are non-linear and express a level of uncertainty observed only during war. And thus in an uncertain world history does not necessary repeat itself. Learning from experience for managing an uncertain phenomenon like disaster helps.

Similarly climate change uncertainties should be considered strongly to make effective impacts on disaster risk reduction.

Available observations indicate that regional changes in climate like temperature rises have already affected a diverse set of physical and biological systems in different parts of the world. Climate change impacts are found to be most severe in the grassroots-level community in the form of natural disasters. Climate change locally could also be due to development like infrastructural constructions, felling of trees, forceful drying up of water bodies etc. The impacts of climate change are observed in the form of increasing poverty vulnerability in rural areas. Although communities are equipped with traditional knowledge, new practices (appropriate technology) are required to enable them to cope with the changing climate, thereby providing them with means to sustain their livelihoods. Adaptation to climate change provides the potential to substantially reduce many of the adverse impacts and increase the beneficial impacts, though neither without cost nor without leaving residual damage however flexibility in approach and utilization of local resources (as some tribes follow in Arunachal Pradesh) are the need of the hour. The management process will have to cope with rapid transformation.

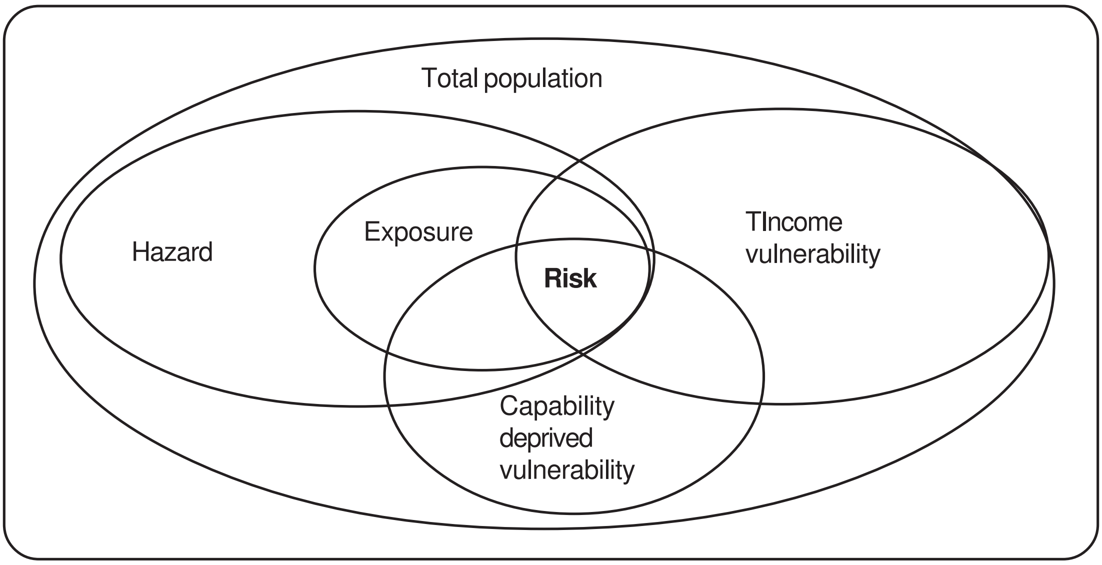


Fig.5.2—Interaction of disaster (hazard, exposure), income and capability deprived vulnerability, and risk.

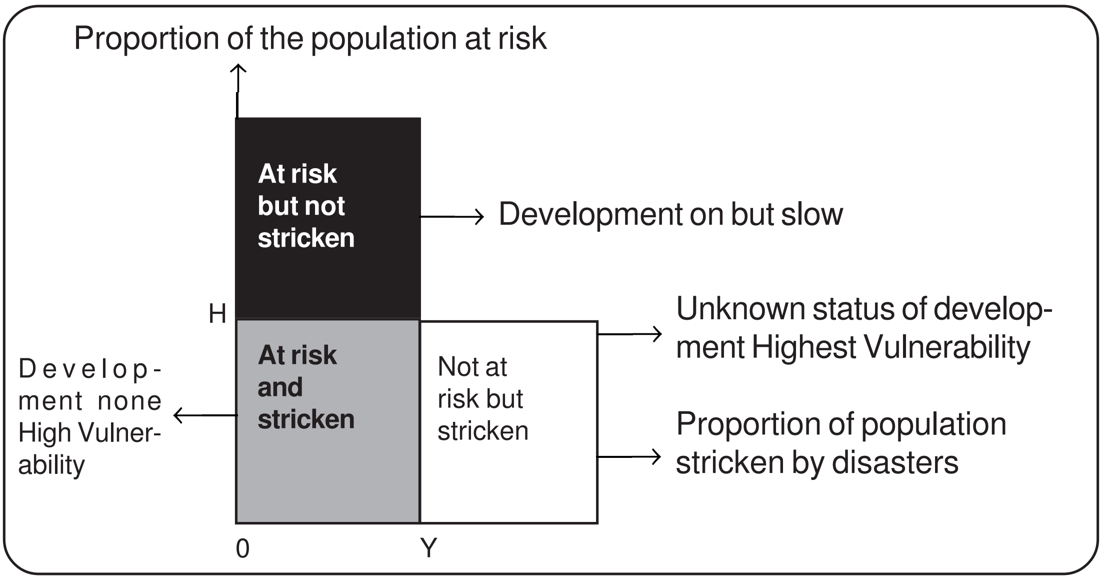


Fig.5.3—Measurement of disaster-poverty — Vulnerability chain

Paper 6
Industrial Hazard Risk Management

Unit 1 ❑ Industrial Disaster Risk Reduction and Emergency Management

Structure

1.1 Introduction

Industries have a wide variety of process involving consumption, production and storage of chemicals The condition that contributes to the danger, by these chemicals, are when these chemicals are not kept/stable at normal pressure and temperature. Hence these chemicals are kept at/or high pressure and temperatures; the gases are liquefied by refrigeration to facilitate storage in bulk quantities. Under these circumstances, it is essential to achieve and maintain high standards of plant integrity through good design, management and operational controls. Given the large quantities of potentially hazardous materials which are handled daily without incident, it is clear that the controls and safeguards which have been developed by the industry are effective. However, accidents do occur and these can cause serious injury to employees or to the public, and damage to property. Most disastrous events like the Bhopal tragedy have emphasized the need to address both on-site and off-site safety The public concern at such events invariably leads to call for additional control at national and international levels. It is against this background that the various Section and Rules under the Environment Protection Act, 1986, the Factories Act, 1948 and other Acts specify the requirements for a safe and reliable working of an industry These require carrying out various studies and analysis to assess and mitigate hazards prevalent in the factory in line with the above goal of safe and reliable working. These are more commonly known as “Risk Assessment Studies”. This chapter explains the basis of Risk Assessment and its objectives.

It is most important that one knows his region or one’s industry. it is also emphasized that he knows the risks around himself.

Althogh the consequences of risks can be similar, knowing the risks specific to his region can help to prepare himself, his family and the community better.

Across India, we face a number of hazards from earthquakes, landslides, through supercyclones, cyclones, tsunamis, floods and storms to droughts. In addition there are often types of risks, such as industrial or trnasportation incidents and the possibility of acts of terrorism.

Disaster Risk Management Place and Preparation involve a detailed preparation of all types of risks, as assessed.

1.2 Objective of the Study

The main objectives of the Risk Assessment Studies are as given below:

1) To define and assess emergencies, including risk impact assessment.
2) To control and contain incidents.
3) To safeguard employees and people in vicinity.
4) To minimize damage to property and environment.
5) To inform the employees, the general public and the authority about the hazards / risk assessed, safeguards provided, residual risk if any and the role to be played in them in the event of emergency.
6) To be ready for mutual aid if need is arise to help neighboring unit. Normal jurisdiction of an OEP in the own premises only, but looking to the time factor in arriving the external help or off - site emergency plan agency, the jurisdiction must be extended outside the extent possible in case of emergency occurring outside.
7) To inform authorities and mutual aid centers to come for help.
8) To affect rescue and treatment of casualties. To count injured.
9) To identify and list any death.
10) To inform and help relatives.
11) To secure the safe rehabilitation of affected areas and to restore normalcy.
12) To provide authoritative information to the media.
13) To preserve records, equipments, etc.. and to organize investigation into the cause of emergency and preventive measures to stop its recurrences
14) To ensure safety of the workers before personnel re
15) To work out a plan with all provisions to preparedness and the periodical rehearsal of the plan.

1.3 Philosophy and Methodology of Risk Assessment

Major hazard installations have to be operated to a very high degree of safety; this is the duty of the management. In addition, management holds a key role in the organization and implementation of a major hazard control system. In particular, the management has the responsibility to

i. Provide the information required to identify major hazard installations;
ii. Carry out hazard assessment;
iii. Report to the authorities on the results of the hazard assessment;
iv. Set up an emergency plan;
v Take measures to improve plant safety.

In order to fulfill the above responsibility, the Management must be aware of the nature of the hazard, of the events that cause accidents and of the potential consequences of such accidents. This means that in order to control a major hazard successfully, the Management must have answers to the following questions;

a Do toxic, explosive or flammable substances in our facility constitute a major hazard?
b Which failures or errors can cause abnormal conditions leading to a major accident?
c. I f a major accident occurs, what are the consequences of a fire, an explosion or a toxic release for the employees, people living outside the factory, the plant or the Environment?
d. What can Management do to prevent these accidents from happening?
e. What can be done to mitigate the consequences of an accident?

The most appropriate way of answenng these questions is to carry out a hazard or risk assessment study, the purpose of which is to understand why accidents occur and how they can be avoided or at least mitigated A properly conducted assessment will therefore

i. Analyze the existing safety concept or develop a new one;
ii. Identify the remaining hazards; and
iii. Develop optimum measures for technical and organization protection in event of an abnormal plant operation.

1.4 Identification of Hazards

- **MAJOR HAZARDS**

Hazard is the associated term with material.which is a measure or the likely hood of the human working with ,or studying the material in question All the probable potential hazard is classified under different heads

1 Fire hazards
2 Toxic gas release hazards
3. Explosion hazards
4 Corrosion hazards

- **FIRE HAZARDS**

Since the Stone Age term „fire is associated with fear. It is very dangerous if occurs in uncontrolled manner It should be clearly understood that when a liquid is used having flash point below the normal ambient temperature, it could, in suitable circumstances, liberate a sufficient quantity of vapour to give rise to flammable mixtures with air

- **TOXIC HAZARDS**

Toxic substances affect in three ways by ingestion, adsorption & inhalation which are describe below

- **CORROSION HAZARDS**

Corrosion is a chemical reaction-taking place at the surface of metal

Potential Health Effects:

Eye Contact:

Airborn dust may cause immediate or delayed irritation or inflammation Eye contact with large amounts of clinker dust and dry cement powder can cause moderate eye irritation, chemical burns and blindness Eye contact with large amounts of gypsum can cause moderate eye irritation, redness, and abrasions Eye exposures require immediate first aid and medical attention to prevent significant damage to the eye

Skin Contact:

Dust of clinker, gypsum and cement may cause dry skin, discomfort, irritation, severe burns and dermatitis. Clinker dust and cement dust are capable of causing dermatitis by irritation. Skin affected by dermatitis may include symptoms such as, redness, itching, rash, scaling and cracking. Irritant dermatitis is caused by the physical properties of clinker dust including alkalinity and abrasion.

Inhalation (acute):

Breathing dust may cause nose, throat or lung irritation, including choking, depending on the degree of exposure. Inhalation of high levels of dust can cause chemical bums to the nose, throat and lungs.

Inhalation (chronic):

Risk of injury depends on duration and level of exposure This product contains crystalline silica Prolonged or repeated inhalation of respirable crystalline silica from this product can cause silicosis, a seriously disabling and fatal lung disease Some studies show that exposure to respirable crystalline silica (without silicosis) or that the disease silicosis may be associated with the increased incidence of several autoimmune disorders such as scleroderma (thickening of the skin), systemic lupus erythematosus, rheumatoid arthritis and diseases affecting the kidneys. Silicosis increases the risk of tuberculosis.

Ingestion:

Internal discomfort or ill effects are possible if large quantities are swallowed

- **EXPLOSION HAZARDS**

  Release of energy in rapid and uncontrolled manner gives rise to explosion

- **EXPOSURE LIMITS**

  The exposure limits for Portland cement, gypsum, crystalline silica and calcium carbonate are as given in the following table-6.1

TABLE - EXPOSURE LIMITS

SR.NO.	CHEMICALS	ACGIH TLV-TWA (MG/M3)
1	Portland Cement	10 mg total dust/m 3
2	Calcium Sulfate dehydrate (gypsum)	10 mg total dust/m 3
3	Crystalline Silica	0.05 mg respirable quartz/m 3
4	Calcium carbonate	10 mg total dust/m 3

FIRST AID MEASURES

Following first aid measures shall be taken.

Eye Contact:

Rinse eyes thoroughly with water for at least 15 minutes, including under lids, to remove all particles Seek medical attention for abrasions and burns.

Skin Contact:

Wash with cool water and a pH neutral soap or a milk skin detergent Seek medical attention for rash, bums, irritation and dermatitis.

Inhalation:

Move person to fresh air. Seek medical attention for discomfort or if coughing or other symptoms

Ingestion:

Do not induce vomiting. If conscious, have person drink plenty of water Seek medical attention.

1.5 Exposure Controls and Personal Protection

Exposure Controls:

- Control of dust through implementation of good housekeeping and maintenance;
- The bag filters will be installed to control dust emission.
- Use of PPE, as appropriate (eg masks and respirators)
- Use of mobile vacuum cleaning systems to prevent dust buildup on paved areas;

Personal Protective Equipment (PPE):

- Respiratory Protection: When the dust level is beyond exposure limits or when dust causes irritation or discomfort use Respirator
- Eye Protection: Wear Safety goggles to avoid dust contact with the eyes Contact lenses should not be worn when handling the materials.
- Skin Protection: Wear impervious abrasion and alkali resistant gloves, boots, long sleeved shirt, long pants or other protective clothing to prevent skin contact.

1.6 Other Safety Measures

- Safety training to the workers will be given
- PPE will be provided to the workers
- The maintenance and cleaning of bag filters will be carried out regularly
- The dust removal efficiency of bag filters will be check regularly
- Work place environment monitoring will be carried out regularly and records will be maintained. The monitoring of cement dust and silica in the work place will be carried out.
- Good house keeping will be implemented in the plant
- First aid box will be provided.
- The industry will provide adequate lighting facility inside the plant premises
- General dilution ventilation will be provided to control dust levels below applicable exposure limits.
- Fire extinguishers will be provided to withstand the fire or explosion condition
- Pre-employment and periodical medical examination of workers will be done by government approved medical practitioners and the details will be recorded as per the Regulations.
- The industry will prepare on-site emergency plan.
- In case any emergency, arrangement of ambulance van will be done from Guwahati
- Two main gates will be provided for entry and exit of the workers
- Work place environment monitoring for cement dust and silica will be carried out

1.7 Occupational Health of the Workers

Health hazards associated with the occupation are called occupational hazards in Cement industry the major sources of emission are:

1. Raw material handling: Total Dust or Suspended Particulate Matter
2. Raw Mill Section: Total Dust or Suspended Particulate Matter.
3. Cement Grinding Unit. Total Dust «#r Suspended Particulate Matter.

All precautions would be taken to avoid foreseeable accident like spillage, fire and explosion hazards and to minimize the effect of any such accident and to combat the emergency at site level in case of emergency Some of the preventive safety measures to minimize the risk of accident with respect to Technical Safety, Organizational Safety and Personal Safety are listed below:

- The factory will take all reasonably practicable measures to minimize the risk of such accident in compliance with the legal obligation under the relevant safety.
- All building plans and installations are as per relevant acts and duly approved by competent government authorities.
- Process and Equipment will be designed by qualified and experienced professionals and fabricated to applicable national / international codes with stage wise inspection.
- Safety features such as fire extinguisher and suitable Personal Protective Equipment (PPE) shall be provided. Regular operations and testing of fire extinguishers shall be carried out.
- Periodic inspection and testing of pressure vessels, equipment, machineries and equipment handling substances.
- Training of workers and Staff for fire fighting, work permit system, first aid, safe handling of materials and integrating safety, in all activities.
- Accident / Incident reporting system and information of employees about the same for better awareness.
- Suitable notices / boards displayed at several locations indicating appropriate hazards warning as well as DOs and DON T for ensuring operational and personal Safety for information of workers / staff and visitors.

For the safety of the workers, personal protective equipments like hand gloves, helmets, safety shoes, goggles, aprons etc. & Ear protecting devices like earplugs/earmuffs will be provided. Nose mask will be provided at places, where there is possibility of dust generation

1.8 Noise Exposure

Sources:

Grinding mills. Compressors, Fans, Blowers, Material handlers, Crushers and DG sets.

Effects:

Hearing impairment, Hypertension, Ischemic heart disease. Annoyance, Sleep disturbance.

Attenuation And Conservation:

Tools for assessing noise levels A successful noise control program that focuses on engineering control of noise requires the institution of a hearing conservation plan and the use of proper monitoring equipment, surveys, maps, and modeling.

A thorough hearing conservation plan should be established where noise exposure exceeds a 85-dBA time weighted average for eight hours. A good program consists of the following components:

- Noise measurement and analysis;
- Engineering control of noise sources where feasible;
- Administrative controls and personal protection where noise control is not feasible;
- Audiometric testing;
- Employee training and education;
- Record keeping; and
- Evaluation

Control Measures :

- Introducing good acoustic design for the new production line
- Adopting proper scheduling of construction activities
- Scheduling noisy activities during the daytime periods
- Operating well-maintained mechanical equipment on-site
- Ensuring that equipment that may be intermittent in use should be shut down between work periods or should be throttled down to a minimum
- Installing rubber coating in dumpers and entry chutes
- Using personnel protection gear such as earplugs, muffs, etc.
- Developing a greenbelt around the quarry area
- Controlling air-flow generated noise by adopting adequate sizing of inlet/outlet ducts
- Installing noise barriers around air blowers, pumps, and genrators to reduce noise impacts at nearby receptors
- Devising and implementing a rigorous inspection and maintenance program applicable to exquipment on-site

1.9 Heat Stress

Aim is to maintain body core temperature withing +1°C of normal (37°C). This core body temperature range can be exceeded under certain circumstances with selected populations, environmental and physiologic monitoring, and other controls.

Source :

- High temperature and humidity; direct sun or heat; limited air movement; physical exertion; poor physical condition; some medicines; inadequate tolerance for hot workplaces; and insufficient water intake can all lead to heat stress.

Different kind of heat disorders and health effects are possible and how should they be treated?

Sr. No.	Definition	Primary Signs and Symptoms	Medical Treatment
1.	**Heat Stroke :** Most serious heat related disorder when the body's temperature regulation fails and body temperature rises to critical levels. It is a medical emergency may result in death	Confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating (usually); hot, dry skin; and an abnormally high body temperature	Placed worker in a shady, cool area and the remove outer clothing; Provide the worker fluids (preferably water); circulate air to improve evaporative cooling
2.	**Heat Exhaustion :** Partly due to exhaustion; it is a result of the combination of excessive heat and dehydration	headache, nausea, dizziness, weakness, thirst, and giddiness; Fainting or heat collapse	Remove from the hot environment and give fluid replacement. Encourage getting adequate rest, and when possible, ice packs should be applied.
3.	**Heat Cramps :** Caused by performing hard physical labor in hot environment.	electrolyte imbalance caused by as weating and are normally caused by the lack of water replenishment	Workers in hot environments drink water every 15 to 20 minutes and also drink carbohydrate-electrolyte replacement liquids
4.	**Heat Rashes :** the skin is persistently wetted by unevaporated sweat	a red cluster of pimples or small blisters mainly in neck and chest, in the groin, under the breasts, and in elbow creases	Provide a cooler, less humid upper environment, powder may be used to increase comfort, avoid using ointments or creams

Administrative or work practice controls to offset heat effects :

- Provide accurate verbal and written instructions, annual training programs, and other information about heat stress
- Acclimatize workers by exposing them to work in a hot environment for progessively longer periods.
- Replace fluids by providing cool water or any cool liquid (except alcoholic and caffeinated beverages) to workers and encourage them to drink small amounts frequently, e.g., one cup every 20 minutes. Ample supplies of liquids should be placed close to the work area.

- Reduce the physical demands by reducing physical exertion such as excessive lifting, climbing, or digging with heavy objects. Use relief workers or assign extra workers, and minimize overexertion.
- Provide recovery areas such as air-conditioned enclosures and rooms and provide intermittent rest periods with water breaks.
- Reschedule hot jobs for the cooler part of the day, and routine maintenance and repair work in hot areas should be scheduled for the cooler seasons of the year.
- Monitor workers who are at risk of heat stress, such as those wearing semi-permeable or impermeable clothing when the temperature exceeds 70°F, while working at high energy levles. Personal monitoring can be done by checking the heart rate, recovery heart rate, and oral temperature.

ILLUMINATION

Sr. No.	Location	Illunination by	Illumination in Lux
1.	Low roof buildings	Fluorescent tube lights	100-150/300 (control rooms)
2.	Shops/High roof building	HPSV lamps	100-150
3.	High color rendering	Metal halide lamp fittings	required (low color distortion)
4.	Open yard and area illumination	HPSV flood light fittings	15-30

The use of energy saving. Power factor lamp fittings shall be preferred.

1.10 Ergonomics

Ergonomics is the term applied to the field that studies and designs the human-machine interface to prevent illness and injury and to improve work performance. It attempts to ensure that jobs and work tasks are designed to be compatible with the capabilities of the workers.

Source :

Some physical agents play an important role in ergonomics such as Force, Acceleration and Thermal factors. Force is an ‘‘important casual agent in injuries from lifting. Other important ergonomic considerations include work duration, repetition, contact stresses, postures, and psychosocial issues.

Work-Related Musculoskeletal Disorders :

Work-related musculoskeletal disorders (MSDs) are an important occupational health problem that can be managed using an ergonomics health and safety program. The term musculoskeletal disorders refers to chronic muscle, tendon, and nerve disorders caused by repetitive exertions, rapid motions, high forces, contact stresses, extreme postures, vibration, and/or low temperatures. Other commonly used terms for work-related musculoskeletal disorders include cumulative trauma disorders (CTDs), repetitive motion illnesses (RMIs), and repetitive strain injuries (RSIs). Some of these disorders fit established diagnostic criteria such as carpal tunnel syndrome or tendinitis. Other musculoskeletal disorders may be manifested by nonspecific pain. Some transient discomfort is normal consequence of work and is unavoidable, but discomfort that persists from day to day or interfered with activities of work or daily living should not be considered an acceptable outcome of work.

Control Strategies :

The incidence and severity of MSDs are best controlled by an integrated ergonomics program. Major program elements include :

Recognition of the problem,
Evaluation of suspected jobs for possible risk factors,
Identification and evaluation of causative factors,
Involvement of workers as fully informed active participants, and
Appropriate health care for workers who have developed musculoskeletal disorders.

General programmatic controls should be implemented when risk of MSDs is recognized. These include :

Education of workers, supervisors, engineers, and managers;
Early reporting of symptoms by workers; and
Ongoing surveillance and evaluation of injury, health and medical data, Job-specific controls are directed to individual jobs associated with MSDs. These include engineering controls and administrative controls.
Personal protection may be appropriate under some limited circumstances.

Control Measures :

Among engineering controls to eliminate or reduce risk factors from the job, the following may be considered :

Using work, methods engineering, e.g., time study, motion analysis, to elimiante unnecessary motions and exertions.
Using mechanical assists to eliminate or reduce exertions required to hold tools and work objects.
Selecting for designing tools reduce force requirements, reduce holding time, and improve postures.
Providing user-adjustable workstations that reduce reaching and improve postures.
Implementing quality control and maintenance programs that reduce unnecessary forces and exertions, especially associated with non value-added work.

Administrative controls reduce risk through reduction of exposure time and sharing the exposure among a larger group of workers. Examples include :

Implementing work standards that permit workers to pause or stretch as necessary but at least once per hour.

Re-allocating work assignments (e.g., using worker rotation or work enlargement) so that a worker does not spend an entire work shift performing high-demand tasks.

Due to the complex nature of musculoskeletal disorders, there is no ''one size fits all'' approach to reducing the incidence and severity of cases. The following principles apply to selecting actions :

Appropriate engineering and administrative controls will vary from industry to industry and company to company.

Informed professional judgment is required to select the appropriate control measures.

Work-related MSDs typically require periods of weeks to months for recovery.

Control measures should be evaluated accordingly to determine their effectiveness.

1.11 Occupational Health Surveillance of the Worker

The company authorities shall carry out the following Health surveillance :

i) Pre-employment medical check up at the time of employment.

ii) Periodical medical check up shall be done for all employees as :

1. <30 Once in five years
2. 31-40 Once in four years
3. 41-50 Once in two years
4. Above >50 years once every year

iii) First aid training shall be given to the employees.

iv) Monitoring of occupational hazards like noise, heat, chemical (Raw materials & Product) exposure shall be carried out at frequent intervals, the records of which shall be documented.

v) Evaluation of health of workers viz. chest x-ray, Audiometry, Spirometry Vision testing (Far & Near vision, colour vision and any other ocular defect) ECG, during pre-employment and periodical examinations shall be carried out.

Unit 2 ❒ Disaster Management Plan (Emergency Management Plan)

Structure

2.1 Introduction

An emergency is said to have arisen when operators in the plant are not able to cope up with a potential hazardous situation i.e. loss of control of an incident causes the plant to go beyond its normal operating conditions, thus creating danger. When such an emergency evolves, chain of events affect the normal working within the factory area and/or which may cause injuries, loss of life, substantial damage to property and environment both inside and outside the factory and a disaster is said to have occurred. The various steps involved in the process of disaster management can be summarized as:

1. Minimize risk occurrence (Prevention)
2. Rapid control (Emergency Response)
3. Effectively Rehabilitate Damaged Areas (Restoration)

Disaster management plan is evolved by careful scrutiny and interlinking of
(a) Types and causes of disaster.
(b) Technical know-how
(c) Resource availability

2.2 Objectives of Plan

The plan is developed to make best possible use of resources to

— Rescue the victims and treat them suitably.

— Safeguard others (evacuating them to safer places).
— Contain the incident and control it with minimum damage.
— Identify the persons affected.
— Preserve relevant records and equipment needed as evidence in case on an inquiry.
— Rehabilitate the affected areas.

Identification of Major Hazards

— Fire hazard
— Earthquake hazard

Scope of Plan

The plan will set into action immediately after a fire occurs inside the plant. However, fire hazard will be restricted to fuel storage area only and hence no major disaster is envisaged.

Basis of Plan

The company will prepare an onsite emergency plan. The basic guidelines of the plan are as given below:

1. Informative brochure on emergency will be distributed to each staff member of the plant and telephone numbers of key personnel to be contacted during an emergency will be placed at all the operator placement point in the plant
2. Company will have a direct tele-link service line with the central control room as well as nearest fire station in case of severe emergency
3. Workers would be trained regularly on fire hazard drill, which will be organized once in a month by the safety and fire department.
4. Various locations would be covered with fire hydrant system that would be tested and put into operation in such a manner that it remains operational during emergency.
5. 24 hours vehicle for service and in- plant first aid emergency kit would provide.

2.3 Post Disaster Analysis and Evaluation

When an emergency is over, it is desirable to carry out a detailed analysis of the causes of the accident to evaluate the influence of various factors involved and to propose methods to eliminate or minimize them in future simultaneously, the adequacy of the disaster preparedness plan will be evaluated and any short comings will be rectified.

2.4 The Availability, Organization and Utilization of Resources for Emergencies

In order to maintain emergency response capability, certain facilities must be kept in a state of readiness, and sufficient supplies and equipment must be available. Typical examples are:

Emergency operation center
Communication equipment
Alarm systems
Personal protection Equipment
Fire fighting facilities .equipment and supplies
Spill and vapour release control equipment and supplies
Medical facilities .equipment and supplies
Monitoring systems
Transportation systems

Security and access control equipment It is the responsibility of the plant management to ensure that the appropriate equipment and materials are available to respond to their very hazard- specific emergencies at the facility.

One of the most important objectives of emergency planning is to create a response organization structure capable of being deployed in the shortest possible time during an emergency. Command and control of an emergency condition encompasses the key management functions necessary to ensure safeguard of the health and safety of employees, as well as the public living in the vicinity These primary functions are as follow:

Detection of the emergency condition
Assessment of the condition
Classification of the emergency
Mitigation of the emergency conditions
Notification to management personnel
Notification to local, state and government agencies
Activation and response of the necessary onsite and off- site support personnel
Continuous assessment and reclassification, as necessary
Initiation of protective actions
Aid to affected personnel
Recovery and re-entry

The key personnel shall be nominated with special responsibilities according to the laid down procedures and to make the best use of available resources, the key personnel are as under:

Alarm raiser
Incident controller
Site main controller
Essential workers
Other key personnel

The responsibilities of the above key personnel are as described below:

2.5 Incident Controller (IC)

His responsibilities include:

1. As soon as the sound of siren or bell is heard, he will arrive at the site of incident.
2. Take the charge of the scene of the incident
3. To assess the scale of emergency. If the emergency is minor, he will start to activate on - site plan
4. As per the incident, direct the essential workers to prevent it by using extinguishers in case of fire, by covering the liquid spillage by sand or suitable materials in case of liquid.
5. Direct the shut down of the plant or part of the plant and evacuate the plant personnel to assembly point.
6 Direct all operations within the affected areas with the following priorities.
   (a) Secure the safety of personnel
   (b) Minimize loss of material.
   (c) Minimize damage to plant, property and environment.
7. To search for casualties.
8. To brief site main controller and keep informed of development of situation.
9. To preserve evidence that will be necessary for subsequent inquiry into the cause of emergency and concluding preventive measures

2.6 Site Main Controller (SMC)

He is the head authority of the organization. He will have over all responsibility for directing operating and calling for outside help from emergency control centre.

The site main controller shall wear white helmet for his easy identification the responsibilities and duties of the site main controller include:

1. Relieve the incident controller of his responsibilities of over all charge of main control.
2. On consultation with incident controller and other key personnel, decide about the type of emergency.
3. To ensure that key personnel are caller in

4. To continuously review and assess possible developments to determine the most probable cause of events
5. To direct the safe closure of the plant and evacuate the plant incident controller and other key person.

2.7 Essential Workers (EW)

As soon as the essential workers hear the emergency siren or any emergency brought to the knowledge, they will first report to the incident controller. The team of essential workers trained in fire lighting and first -aid will be made available in the factory round the clock in all shifts Their responsibilities include:

1. To fight fire till a fire brigade takes the charge
2. To help the fire brigade and mutual aid teams.
3. To do emergency engineering work like isolation of equipment, materials, process, providing temporary by-pass line for safe transfer of materials, urgent repairs and replacement, electrical work etc
4. To provide emergency services like power, water, lighting, instrument, equipment etc.
5. To move equipment, special vehicles and transport to or from the scene of incident
6 To provide first aid and medical help
7 To carry out atmospheric tests and pollution control.

2.8 Other Key Personnel

Other key personnel are required to provide advice and to implement the decisions taken by the site main controller in the light of information received on the situation from the site emergency. The responsibilities and duties of key personnel include:

(1) Safety :

The safety officer /supervisor will carry out the following:

a) To provide necessary equipment like Fire Fighting Equipment (FFE) and Personal Protective Equipment(PPE)
b) To accompany factory inspector during investigation of the emergency
c) To train workers /supervisors in safety and safe operating procedures.
d) To assist the site main controller, incident controller in preparing a brief report of the incidents

(2) Assembly Points :

The assembly points for gathering non -essential workers / persons will be fixed and will be clearly marked as per the wind direction.

(3) Fire Control Arrangements :

Fire fighting trained personnel will be made available in all the shift The responsibilities and duties include:

(a) To fight the fire with available internal Fire Fighting Equipment.
(b) To provide personal protective Equipment to the team.
(c) To cordon the area and inform incident controller or site main controller about the development of emergency
(d) To trained personnel (essential workers) to use Personal Protective Equipment and Fire Fighting Equipment.

(4) Medical Arrangement :

The responsibilities and duties include:

a) To provide first aid to the affected persons, and if necessary, send them to hospitals for further treatment
b) To keep a list of blood groupings ready and updated.

(5) Transportation and Evacuation Arrangement :

For transportation of people, company s vehicles, cars, rickshaws etc. will be utilized. The hazard in the proposed cement plant is mainly associated with cement production phases and results in the form of dust, noise and fire.

The main hazards during the transportation and storing of material are:
The airborne dust created during the storage of material.
The conveyor belts during their normal operation as well as during their maintenance

In order to reduce the risk from airborne dust
To use dust suction systems
To implement the necessary procedures for the routine cleaning of the settled dust
In material transport systems there are moving parts that are a constant source of hazard for any persons working near these conveyors during normal operation or during the maintenance activities For the safe operation of material transportation system all the necessary guards are applied to isolate the moving parts. Additionally where personnel is working at a short distance from the guards, emergency stops are provided within

short distance of these operators During the normal operation of the transportation systems:

The removal of guards by unauthorized personnel must be prevented.

Any maintenance work during the operation of the transportation system must be avoided.

Removing material during the operation of the conveyors must be avoided.

The cleaning of overflows during operation must be avoided unless the cleaning is done by the conveyor operatives.

The use of unauthorized passageways either over or under the transportation system must be avoided because there is the risk of personnel getting trapped by the conveyor or overflowing material can fall from height.

The overhead bridges must be clean in order to minimize the possibility of the tripping and falling of the personnel performing the checks on the conveyor belts.

Any intervention on the conveyor belt overload systems must be done by authorized personnel.

Unit 3 ❐ Industrial Hazard Management of a Standard Pharma & Health Co.

Structure

3.1 About various useful Definitions

In order to understand the effect and damage consequences arising out of abnormal situations, concepts that are accepted by all the concerned Government, Semi-Government bodies and institutions are defined hereunder:

➢ **Safety**
Prevention & Control of an accident, Freedom from unacceptable Risk or Harm.

➢ **Accident**
An accident is an unplanned event, which has a probability of causing physical injuries,

diseases to the employees or people or damage or destruction or loss of property to the company or any combination of these effects.

➢ **Major Accident**

A major accident is a sudden, unexpected, unplanned event resulting from uncontrolled developments during an industrial activity, which causes, or has the potential to cause

(a) Serious adverse effects immediate or delayed resulting to death, injuries, poisoning or hospitalization to a number of people inside the establishment and / or to persons outside the establishment, or
(b) Significant damage to crops, plants or animals, significant contamination of land, water or air, or
(c) An emergency intervention outside the establishment e.g. evacuation of local population, stopping of local traffic, or
(d) Significant changes in the process operating conditions, such as stoppage or suspension of normal work in the concerned plant for a significant period of time, or
(e) Any combination of above effects.

➢ **Emergency**

- **"Emergency" means a situation leading to a circumstances or set of circumstances in which there is danger to the life or health of the person or which could result in big fire or explosion or pollution to the work and outside environment, affecting the workers or neighborhood in a serious manner, demanding immediate action,**
  {Definition: As per GFR-1963, Schedule - XIX, Part - I, 2(j)}.
- **Emergency situation may exist due to uncontrolled reaction, fire, gas leakage, Uncontrolled spillage of hazardous material (failure of power, water air, steam, cooling media, scrubbing media) etc.**
- It may require outside help also.

➢ **Major Emergency**

A major emergency occurring at a work is one that may effect several departments and/or may cause serious injuries, loss of lives, extensive damages to property or serious disruption outside the works. It will require the use of outside resources to handle it effectively.

Usually the result of a malfunction of the normal operating procedures, it may be precipitated by the intervention of an outside agency, such as a severe electrical storm, flooding crashed aircraft or deliberate acts of arson or sabotage.

Emergency due to operating conditions such as uncontrolled reaction, small fire, small gas leak, spill, failure of power, water air, steam, cooling media, scrubbing media etc. and which can be locally handled by plant personnel alone without outside help is not considered as major emergency. Operating instructions in the safety Manual shall cover this area, though the onsite emergency plan will also be helpful.

➢ **Hazard**

Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these.

➢ **Risk**

Combination of the likelihood and consequences of a specified hazardous event occurring.

➢ **The On-site Emergency Plan**

The on-site emergency plan deals with measures to prevent and control emergencies (which arise in premises) affecting people and the environment inside the premises.

➢ **The Off-site Emergency Plan**

The off-site emergency plan deals with measures to prevent and control emergencies (which arise in premises) affecting public and the environment outside the premises.

The manufacturer should provide the necessary information about the nature, extent and likely hood effects of such incidents to nearby locality.

3.2 About Objectives of the Emergency Plan

Emergency planning is a management function. Managements should evaluate the activities, operations and processes carried out within the works before starting the plans for emergency operations.

Considering our number of employees, materials and processes, availability of resources, location of site, size and complexity of the works, this emergency plan is being prepared.

The Objectives of the Emergency Plan

(a) To define and to assess emergencies, including risk and environment impact assessment.
(b) To prevent the emergency turning into a disaster.
(c) To safeguard employees and people in vicinity.
(d) To minimise damage to property or/and the environment.
(e) To inform employees, the general public and the authorities about the hazards/risks safeguards residual risk if any and the role to be played by them in the event of emergency.
(f) To be ready for 'Mutual aid' if needed to help neighboring units. Normal jurisdiction of an OEP is the own premises only, but looking to the time factor in arriving, the

external help or off-site plan agency, the jurisdiction must be extended out side to the extent possible in case of emergency occurring outside.

(g) To inform authorities and mutual aid centers to come for help.

(h) To effect rescue and treatment of causalities.

(i) To inform and help relatives.

(j) To secure the safe rehabilitation of affected areas and to restore normally.

(k) To provide authoritative information to the news media.

(I) To preserve records, equipment's etc. and to organize investigation into the cause of the emergency and preventive measures to stop the re-occurrences.

(m) To ensure safety at works before personnel re-enter and resume work,

(n) To work out a plan with all provisions to handle emergencies and to provide for emergency preparedness and the periodical rehearsal of the plan.

3.3 About Process, Process Hazards & Control Measures Provided

MANUFACTURING PROCESS & PROCESS FLOW CHART

We are engaged in the manufacturing of pharmaceutical products in the form of Tablets, Capsules, Injectable, and also API.

Above items are manufactured in two different plants, they are:

A - Formulation Plant
B - API Plant

In our Formulation plant, there are four different departments,

1. Tablet manufacturing
2. Capsule manufacturing
3. Injectable manufacturing department
4. Packaging Department

A - Formulation Plant:

TABLET MANUFACTURING PROCESS

1. Shift or pulverize all raw materials to be used in the product, which are dispensed after weighing.
2. Mix the active material with diluents using mixer. If necessary do geometrical dilution or triturating.
3. Prepare binder solution or paste using binder in appropriate solvent as per formulation requirement.
4. Bind the mixed powder using binder in mixer.
5. Wet granulates the mixed mass using comminuting mill fitted with perforated screen.
6. Dry the wet granules in Fluid bed Dryer controlling temperature of inlet air.

7. Sift the dried granules through appropriate sieve and pulverize the oversize granules in comminuting mill.
8. Lubricate the sifted granules with freshly shifted lubricants using the mixer.
9. Compress the lubricated granules on suitable rotary compression machine fitted with appropriate die-punch set.
10. If required film coat the tablets using auto coating machine controlling spray rate & drying temperature.
11. If required Sugar Coat the tablets using conventional sugar coating pan controlling average weight of the tablet.
12. Inspect the ready tablets on inspection belt.
13. Repack the tablets suitably in blister, strip or bottles followed by post packing in cartons or boxes.
14. Shrink wraps the boxes and packs them finally in corrugated boxes suitable for dispatches.

Commisioning

(1) Before commissioning, all equipment's and piping shall be cleaned by means of flushing of steam, water, air etc. as per standards system to avoid any blockage and deposit which may cause probiems in safety and quality.

(2) Before commissioning all the equipment's and piping to be pressure tested as standard practice.

Operational Safety

1. All operators & maintenance personnel's concerned with this plant are given data sheets for hazardous chemicals and are trained to combat any leakage spillage etc.
2. Non destructive thickness measurements are carried out regularly to prevent sudden bursting by thinning out of metal by erosion or corrosion through competent person.
3. Safety appliances like PVC suit, hand gloves, safety goggles, helmets etc. are used during material handling. Also emergency air masks will be kept available. Emergency First + Aid kit is kept available in all departments.
4. Preventive maintenance is carrying out to avoid failure.

   Internal and external inspection of vessel, vibration analysis testing of vessels, thickness measurement of piping, inspection and testing of lifting tackles, cranes, bearing, checking is done as per schedule.

Toxic Releases : Controls

Small quantities - say leakage from piping, valves, pin holes etc. will be easily controlled by isolating the equipment/piping etc. & using personal protective equipments like helmet, shoes, hand gloves, air line respirator, breathing apparatus, apron etc.

Spillages, Leakages : Controls

Depending on the leaking rate/source the following actions will be taken.

(a) Isolation/cutting of supply at the leaking point, transfer to some other vessel/ equipment, and using protective appliances like hand gloves, helmets, PVC suits etc.

(b) Dilution/Flushing with large quantities of water Fumes / Vapors to be knocked-down with large quantities of water.

(c) Efforts to be made, to prevent spread of spillage by neutralization/earth barriers.

(d) Outgoing effluents will have to be blocked and taken to effluent pit. It will be discharged after treatment only. Continuous neutralization will also be arranged.

3.4 Hazards in Transportation : Control

We are using highly inflammable chemicals such as Toluene, Methanol, etc. & the medium of supply is road transportation. Therefore, some safety precautions for transportation are required to be followed.

The following safety precautions are recommended during transportation of toxic, inflammable and corrosive chemicals and liquids in tankers, while loading and unloading, transportation and meeting the emergencies arising out of leakages and spillages of hazardous chemicals.

1. Park the vehicle at designated place.
2. Stop the engine.
3. Check up spark arrester.
4. Provide earthing to tanker securely.
5. Ensure that fireman is available near the place with proper equipment's.
6. Connect the piping properly
7. Before start unloading, check that, there should not be any leakage.
8. In case of leakage, immediately attend the leakages & rectify it.
9. After unloading is over, close the lid properly.
10. Vehicle to be started only after removal of all pipelines connected with tanker.

3.5 Safety Instructions for Transportation of Hazardous Chemicals

(a) The name of the chemical along with diamond pictorial sign denoting the dangerous goods should be marked on the vehicle and the packing material.

(b) The name of the transporter, his address and telephone number should be clearly written on the road tanker and on the vehicle.

(c) The important safety precautions should be mentioned on the tanker as a warning label.

(d) The tanker or vehicle should not be used to transport any material other than what is written on it.
(e) Only trained drivers and cleaners should transport hazardous chemicals.
(f) The transporter and the manufacturer must ensure the safe transportation of the material.

3.6 Tankers

(a) The tanker should be checked for its fitness and safe condition before loading.
(b) During loading and unloading, the tanker should be breaked and isolated against any movement.
(c) While loading/ unloading, use safety appliances.
(d) The tanker should not be overloaded beyond the weight permitted by R.T.O.
(e) Check for leakages from the line connections before starting and stopping the filling operations.
(f) Drive the vehicles carefully, especially in crowded localities and on bumpy roads. Do not apply sudden break.
(g) The tanker should not be parked for long time on the way and especially in crowded places. Park the vehicle away from residential areas.

3.7 Other Hazards and Controls

In the factory, in addition to the storage hazards, process hazards and vessel hazards, there are few more hazards having the following details.

(a) Boiler failure hazards.
(b) Non-Chemical vessels failure hazards
(c) Maintenance Hazards
(d) Hazards due to failure of electrical installations.
(e) Physical injuries.

3.8 Boiler Failue Hazard : Control

(a) Boiler is periodically checked and the same is tested by a competent authority.
(b) Routine check-up of the boiler with its all fittings and connections.
(c) Necessary maintenance and repair, of the boiler.
(d) To close down the boiler in emergency.

3.9 Non-chemical Vessel's Failure Hazard : Controls

Due to inferior quality or poor maintenance 6r unsafe working conditions such hazards may take place. To overcome the problem, the following measures are under taken.

(a) Proper maintenance of all machinery's.
(b) Regular checking for corrosion.
(c) Thickness and hydraulic test of vessels.
(d) Guard to the V belt for each motor.
(e) Proper fitting and checking for the electrical connection in the factory.

3.10 Maintenance Hazards

(a) Safety permit system is followed like Hot Work, Cold work, Confined Space Entry,
(b) Preventive maintenance is carried out.
(c) Adequate inventory of spare parts is maintained.
(d) Only compatible parts are used.
(e) Scaffoldings/Ladders are used.
(f) Protective appliances is utilized for protection against fall, hand injury, head injury etc.
(g) Positive insulations are made.
(h) Maintenance procedures are developed.
(i) All physical hazards are eliminated.
(j) Lifting tackles are maintained and examined periodically as per rules & regulation
(k) Hand tools/power tools are used with approved types and of good quality.

3.11 Hazards due to failure of Electrical Installations

Apart from the other possible hazards and their precautions, electrical safety can not be ignored because electrical safety is very vital in an industry dealing with flammable material.

To prevent any threat, the electrical aspects of various sections are inspected on the following basis.

(1) Earthing bonding of equipments/motors/storage tanks etc.
(2) 5 No. D.G. Set provided, to supply the power and to control the process in case of power failure.
(3) Electrical sub-station and M.C.C. Panels.
(4) Electrical fittings and fixtures.
(5) Flame proof electrical motors and junction boxes.
(6) General illumination and emergency lighting arrangements.

3.12 Physical Injuries : Controls

(a) All exposed parts of moving machinery shall be provided with suitable guards for personnel safety.

(b) All openings like sewers, water channels, pits etc. are covered with the frame of metal bar and railings to avoid fall of persons.
(c) Hand railing, toe guards, platforms, supports etc. provided.
(d) All hot surfaces are insulated.
(e) Personnel's are trained for their respective jobs and safety training is also imparted.
(f) Sufficient quantity of safety appliances like hand gloves, PVC suits, face shield/ safety goggles, airline respirators, gumboots etc. are maintained and issued to employees for use.

3.13 About Environmental Impact Assessment Plan

Environmental Impact Assessment Plan can be defined as a document containing environmental analysis which includes identification, interpretation, prediction and mitigation of impacts likely to be caused by proposed action of project.

The environmental elements, which are likely to be affected, are to be identified and categorized as air, water, land, sound, ecology, human aspects economics and resources.

Identification and evaluation is necessary for solid, liquid wastes, quantity and quality, gaseous emissions, displacement, human settlements, landscape, vegetation, water courses, aquatic flora, fauna hazards etc.

To consider the social risk, we have to find out that the details about the people those who are at work on site and for the people those who are living and or working in the vicinity.

Off-site population details can be calculated from the following aspects.

(a) Location and number of people normally reside at night.
(b) Day time variation to this data
(c) The number and location of more vulnerable people
(d) Proportion of people outdoors.

3.14 Emergency Control Mechanism

EMERGENCY DECLARATION:

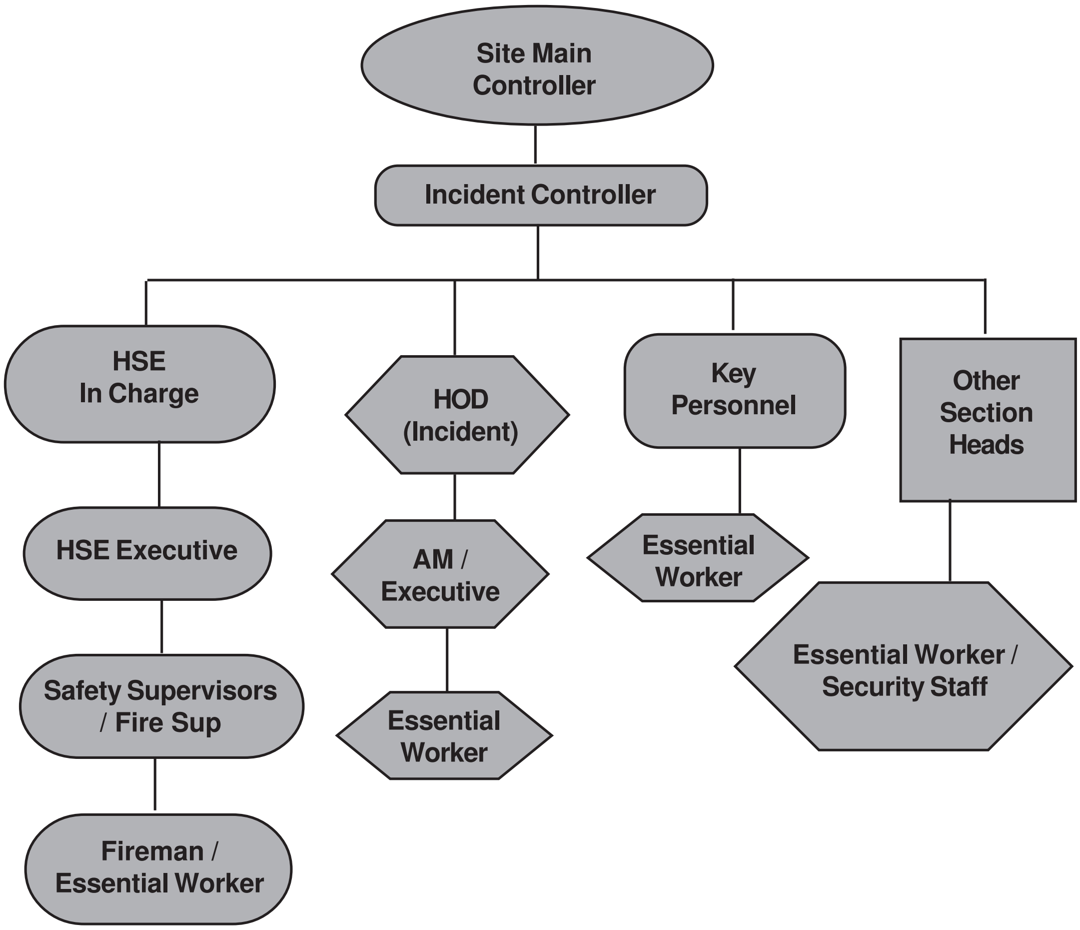
When an incident is reported, it may be emergency & may not be emergency. A decision is to be taken whether emergency is to be declared or not. This will be done by responsible officer who is authorized to do so logically and by experience. He may be plant in-charge or shift executive of the plant or in-charge of location where the incident occurred.

After that emergency is declared, then emergency siren is sounded to alert the people inside the Plant. This siren is indicating that there is something abnormal in the plant, which may leads emergency. After hearing the siren, key persons related to On-site emergency shall report to Incident site.

EMERGENCY SIREN CODE

- ➢ Emergency Declaration Code-Fifteen seconds three times with the gap of five second.
- ➢ Evacuation Code-Start and Stop type continuously for two minutes.
- ➢ All Clear Code-continuously for three minutes.
- ➢ Test Code-Emergency Siren tested on every Saturday at 10.30 a.m. continuously stixy seconds, five seconds gap than seven seconds.

Fig.6.1 ❐ ORGANOGRAM OF EMERGENCY ACTION PLAN



3.15 ❐ The Responsibility of Individuals with respect to the area under emergency as follows

➢ **Site Main Controller (S.M.C.)**

Head of the works will be the S.M.C, in his absence HEAD OF THE PRODUCTION will be the Site Main Controller. He will be overall controller of the emergency. He will take ultimate decision on the following aspects and execute the same with the assistance of concerned personnel :

- Essential Communication.
- Fire Fighting and Rescue Work.
- Emergency Plant Shutdown.
- Demolition and Repair.
- Transportation.
- Investigation.
- Public Relation.
- Urgent Medical Attention and Actions.
- Evacuation and directive to vicinity community through state agencies.

➢ **Incident Controller - Head of the (Production)**

- Assess the emergency.
- Disseminate warning.
- Direct the fire and rescue operation.
- Direct the plant operation/shutdown to control the emergency.
- Liaison with head of the (Egg. Services) / Manager (Mech.).
- Ensure constant feed back to S.M.C.

➢ **Manager / Assistant Manager - Production Deputy - Incident Controller**

- Deploy officers and staff for control room and field for coordinating and directing the work of fire fighting and rescue operation
- Evaluate the risk and its subsequent effects in consultation with Manager / Executive (PPC).
- Function as incident controller in the absence of head of the (Production).

➢ **Manager - Safety**

- Evaluate the hazard and accordingly direct the Safety staff / Fire staff for emergency actions and arrange the safety equipments.

- Keep constant contact with Vice President (Works) through out the emergency.
- Summon help from outside agencies like local fire brigade.

➢ **Safety Staff**

- Direct the crew members in carrying out fire fighting rescue operation and control of toxic chemical release.
- Direct the rescue operations in co-ordination with Safety Manager.
- Provide stretcher service to ambulance point.
- Arrangement and deployment of additional crew (Off duty personnel).
- Ensure adequate supply of fire fighting/rescue equipment, accessories and materials.
- Keep constant touch with Safety Manager / Plant Manager / In charge.

➢ **Head of the - Q.C. / P.D. Lab**

- Evaluate the operational needs on emergency, anticipation of possible risks and suggest suitable measures to Plant Manager / Assistant Manager / In-charge.
- Assessment of magnitude and spread of risk to work out remedial actions.
- Collection and assessment of information on weather condition drain discharge and ambient air quality during emergency shall be decided by Head Q.C. / R & D for enabling public warning / evacuation.
- Deciding the method of disposal of hazardous spillage/leakage.

➢ **Head of the - Utility**

- Check any abnormality and rectify the utility functions
- Ensure that the functions could be used for safety and rescue if necessary.

Unit 4 ❐ The control of Major Hazards in India

Structure

On the advice of ILO mission which visited India during April, 1985, Govt. of India established a major hazards control system for the purpose of :—

a) Identification of major hazards works,
b) A high standard of operation at their works including installation & maintenance of plant;
c) A competent enforcement authority to monitor the above (b).
d) Formulate Emergency planning control system both on SUE & OFF site in the event of a major accident.
e) Information to the public living near to the works and the action that they should take in the event of accident.
f) Planning the use of land near to their works in order to separate center of population from major hazard works.

4.1 Proposed Major Hazard Work Defination

A list of hazards chemicals and flammable substances/ gasses should be established, each having a specific quantity such that any factory storing and using any material above the stated quantity should be a major hazards work by definition. Full information on the properties of the hazardous material should be stored on computer.

The object of ON SITE emergency plan is to take fast & effective action in order to:—

i) Protect the personnel inside & public outside the factory premises,
it) Safeguard the property and environment.
iii) Effect rescue and treatment of casualties.
iv) Bring the incident under control within shortest possible period of time.
v) Preserve relevant records and equipment for the subsequent enquiry.

vi) Ensure rapid return to normal operation after the emergency.

While dealing with emergency plan - the following is to be considered :—

1) Hazard - Size &. nature of the event foreseen,
ii) Risk - The probability of damage that the event could occur/cause
iii) Consequence - The effect on people and on environment both ON-SITE & OFF-SITE

4.2 Major Emergency

A major emergency occurring at a works is one that affects (1) several departments with in it, (ii) May cause serious injuries to human beings, (iii) Losses of life, iv) extensive damage to the property, (v) serious disruption, outside the works, (vi) Pollute the general environment damage to the environment and (vii) it needs evacuation of people.

It requires the assistance of outside agencies and use of outside resource to handle it effectively.

Key Personnel

1) Works incident controller Shift in charge / Plant Manager (overall control of the work process WIC)
2) Works main controller - Sr. Manager - with authority to take decision (WMC),
3) Other key personnel - from branch office, maintenance, Safety personnel and production and security and also factory medical officer.
4) Task force, with suitable trained personnel.

The essential works to be done are as follows during an emergency;

1. Shut down the plant.
2. Isolation / repairing of the affected equipment's / plant/ pipeline etc
3. First-aid and removal of the injured person to hospital
4. Emergency Engineering Works.
5. Acting as a runner to inform emergency service and key personnel in case of communication difficulties

4.3 Emergency Control Centre (ECC)

An emergency control center should be established and equipped with adequate means of communication to area both inside and outside the works together with relevant data, other equipment and facilities. It should be manned by works main controller and should be located at minimum risk area. At least two E.C.C Is preferred, as the one E.C.G may not always be tenable. Good access to the on site as well as outside from the E.C.C is always preferred.

4.4 Outside Emergency Planning Officer (E.P.O.) / District Emergency Authority (DEA)

After formulation of the on-site emergency plant for each hazardous factory, off site emergency plan for the area should be prepared and their off-site planning and action will be decided by the emergency-planning officer deputed by the Govt.

The following & up to date information are essential

(I.) Identification of potential hazards with type of emergency should be established (whether fire or explosion or release of toxic gases). Special care should be taken to identify those hazards, which may affect off site people and property. A list incorporating inventories of the hazardous raw materials, finished products, by products, intermediate and chemicals used for heating, cooling and other purposes should be prepared including all hazardous, toxic, flammable, explosive and corrosive substance in the process as well asjprthe pipe lines. Trade names if any, of the chemical items should be prepared. Trade name of the chemicals should be substituted by actual chemical composition. Synopsis of the plan (1) Minor emergencies will be handled by trained plant personnel with a view to minimize / control the situation by implementing the actions laid down for each type of emergency, (ii) And will require two simultaneous operations one to control the sources of emergency and the other to minimize the lose.

FORMULATION OF THE ON SITE EMERGENCY PLAN:

Method of reporting emergency:

1) An employee while discovering an emergency condition/situation should immediately report/inform it to plant in-charge and other workmen in the area.
2) The aforesaid employee or any other employee who has came to know about the emergency should at the same time raise alarm by shouting and also by sounding the local alarm provided for the purpose.
3) Works Incidents controller or his deputies will immediately assume charge for controlling the situations.

METHOD OF DECLARING EMERGENCY AND ACTIVATING EMERGENCY PLAN:

Nature of emergency (minor or major) should be determined rapidly as it may be of minor or major one. Major emergency will be notified by a two km. range alarm located at suitable place and will be operated for two minutes and resounded thrice after one-minute interval. Minor emergency will be notified by the local alarm located at such place from which the alarm should be audible in every part of the works. Sometimes it is better to provide both audible alarm and flashing of lights.

It is important for every one to know that an emergency occurs as they should be ready to take appropriate emergency action as stipulated in the ON-SITE emergency plan.

Once the declaration for major emergency is made, it is essential that outside emergency services to be informed in the shortest possible time. This responsibility will rest with works main controller.

In absence of WMC, WIC will determine the shutdown priority and call in all key personnel already identified.

During non-business hours or on holiday key personnel will be called in during major emergencies by WMC and in turn key personnel will call their subordinates as per procedures laid down in the plan.

Evacuation :

As precautionary measures it is necessary to evacuate personnel especially non-essential workers from the affected areas and they should be directed to assemble at different assembling points depending upon the wind directions. WIC and WMC will take the decisions in respect of the assembly point or points.

Accounting for personnel:

WIC will arrange for a search to locate any causality at or near the affected area. If necessary Fire Bridge or officer-in-charge of local authority may arrange for further search. Nominated work personnel should record the names of casualties who have been shifted to hospitals or given first - aid. Recording the names of the people reporting to assembly points is also essential.

Access to records:

A list of the names and address of all employees, their department of work and duty chart to be maintained in the Emergency Control Center (E.C.C).

Public Relation :

A Senior Manager should be entrusted for informing news media.

Rehabilitation: The EPO or senior fire bridge officer will not signal the end of emergency until he is satisfied that all fires are extinguished and there is no risk of resignation and / or release of toxic / flammable liquid gas have been properly controlled and released materials properly dispersed off when Emergency planning officer or District emergency authority or other senior officers of the out side emergency services declare the end of emergency by sounding a single continues alarm of three minutes duration.

Relevant records, equipment, etc will be preserved for subsequent enquiry by the authority.

Action Outside the Works :

For controlling or minimising the effects of hazards due to emergency outside the works, an off-site Emergency plans for the area to be formulated or prepared. However for release of Toxic gases or, in case of any major emergency the works Main controller should immediately inform the police and the railway authorities to stop road and rail traffic if the roadway and railway are near the works and likely to be affected by the emergency.

4.5 Emergency Response Procedure

In this case the factory authority will mention the procedures for handling major and minor emergencies for each hazardous chemicals.

- The following procedure will be undertaken in case of any Major Hazards .
- Press the emergency alarm or shout
- Inform WIC (Work Incident Controller)
- WIC will direct to stop all operations of the plant or otherwise according to the need.
- Call essential workers with personal protective equipment and emergency equipment to control the situation at the affected area;
- Call WMC, key personnel, Fire Brigade. Police etc if required. If the above mentioned WMC or WIC are not available or affected by the emergency and if the situation demands so, one of the key personnel present will act as WMC and will take decision to call other WIC from residence or select WIC from the working staff- present. The key personnel call in therefore; have adequate knowledge of the 'ON SITE' Emergency plan.

4.6 Emergency Control Centre

The emergency control center is the place from where the operations to handle the emergency are directed and co-ordinate. WMC, key personnel, the senior officers of the Fire and Police service and other authorities will attend it.

Formulation of the off-site emergency plan:

1. We have already discussed that an emergency may occur despite all the precautionary steps/ measures are taken.
2. The off-site emergency plan should be based on those events identified by the employers in his ON-SITE emergency plan
3. An adequate number of external and internal telephones shall be maintained in the E.C.C.

4. A plan or plans of the works indicating the areas where there are large, inventories of hazardous materials e.g. tanks, reactor, gasholders etc. are stored.
   (a) Location of radioactive sources.
   (b) Sources of safety equipment (personal protective equipment).
   (c) Fire water system and alternative source of water.
   (d) Stocks of Fire extinguishing media.
   (e) Works entrance and road system, assembly points, Casualty treatment center and emergency control center.
   (f) Location of the work in relation to surrounding community.
5. Additional copies of work plans which may be illustrated during the emergency.
6. Arrangement for recording messages and instructions.
7. Normal roll of employees
8. List of key personnel, addresses and telephone numbers
   List of outside Emergency Services and authority along with their addresses and telephone nos. fax and E-mail
   a) Fire Services
   b) Police Station
   c) Hospitals / Medical centers / Ambulance
   d) District Magistrate / S.P and B.D.O
   e) Local Municipality Authorities
   f) Area Factory Inspectorate
   g) Water Supply Authorities
   h) Telephone Authorities
   i) Electricity Authorities
   j) Pollution control authority

Rehearsal and updating of the plan:

Rehearsal and updating of the ON-SIDE plan will be undertaken at an internal of six months. The emergency plan should be reassessed and altered or updated as necessary and the personnel involve should be made aware. Rehearsal is also necessary with a view to test.

(1) Effectiveness of communication.
(2) Key Personnel response time
(3) Decision making
(4) Search and rescue operation
(5) Treatment of casualties
(6) Emergency isolation of plant & equipment and compatibility of the emergency equipment

Formulation of the off-site emergency plan:

1. We have already discussed that an emergency may occur despite all the precautionary steps/ measures are taken.
2. The off-site emergency plan should be based on those events identified by the employers in his ON - SITE emergency plan.
3. The consequent from a release of toxic materials like chlorine, ammonia, and oleum etc. are more difficult to predict due to various factors rather than emergency situations caused due to common hazardous materials like liquefied petroleum gas.

4. **Action to be taken in the event of emergency:**
   - Passing of information's to relevant person / agencies,
   - Warning and advising the persons, who are likely to be affected,
   - Mobilising and gearing up of inside resources,
   - Calling up of outside agencies,
   - Initiating and organising evacuation of such persons,
   - Collecting latest status or developing including information and requirements,
   - Co-ordination between various agencies etc.

In short proposed response to any such incident must be appropriate to the particular situation.

Responsibilities of works Incident Controller:

- On arrival at the place of incident or scene or affected area
- Assess the scale of emergency and decide if a major emergency exists or is likely;

Direct all operations with regards to :

- Secure safety of personnel,
- Minimise damage to plants, properties and the environment.
- Direct rescue, fire fighting and toxic gas control until the arrival of the outside agencies like fire Bridge, etc.
- Ensure that the affected Area is searched for casualties
- Ensure that all non-essential workers in the affected area evacuated to the appropriate assembly point.
- Pending the arrival of the works main controller, assume the duties of the post and direct the shutting down and evacuation of non-essential
- workers and calling the outside - emergency services. Report all significant development to the WMC,
- Provide advice and information as required to the senior officers of the Fire Brigade

- Preserve evidences that will facilitate any subsequent inquiry into the cause and circumstances of the emergency

Responsibilities of works main controller :

- Relieve WIC of responsibility for overall main control,
- On declaration of major emergency, ensure outside emergency services are called in and where necessary nearby factories informed,
- Ensure key personnel are called in,
- Exercise and direct operational control of those parts of the works outside the affected area,
- Maintain a speculative and continues review the incident and determine most probable causes of events,
- Inform police and nearby railway station for holding up the traffic,
- Ensure that casualties are receiving adequate attention and treatment,
- Direct the shutting down and evacuation of plants in consultation with WIC,
- Maintain constant contact with emergency planning officer or District Emergency Authority,
- Ensure the accounting for personnel,
- Control traffic movement within the works,
- Maintain chronological record of the emergency,
- Arrange relief of personnel and catering facilities where the emergency is prolonged,
- Contact the local meteorological office to receive early information of impending changes in weather conditions.
- Ensure that proper consideration is given to the preservation of evidence
- Control rehabilitation of affected areas, on cessation of the emergency.

During emergency, works incident controller and works main controller should wear distinctive garment or helmet so that they are readily recognised.

This model plan has been prepared on the basis of :

(1) Recommended procedures for handling Major Emergencies-a booklet of U.K. Chemical Industrial Association.

(2) Guidelines provided in the manual of ILO mission which visited India in April, 1985.

(3) CIMAH regulations.