

Training Module

Flood Risk Mitigation & Management



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**Gujarat Institute of Disaster Management,
Gandhinagar**

Training Module on Flood Risk Mitigation & Management

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2. Shri. G.K. Bhatt, Executive Director, Taru Leading Edge, Ahmedabad
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Author:

Dr. Sandeep Pandey, Assoc. Prof., GIDM

Course Director

Mr. P.K. Taneja, Director General, GIDM

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Message



Floods are one of the most commonly occurring natural hazards across India and Gujarat state. Floods are caused by rivers, catastrophic rainfall, and the funnel effect of the Arabian Sea. It grimly impacts thousands of people in Gujarat state and cause distress and damage. Flood risk is a combination of hazard, exposure, vulnerability, and all the consequences on the “receptors” – people, property, and the environment.

Flood Risk Management is a process which comprises pre-flood prevention, risk mitigation, preparedness, backed up by flood management actions during and after a flood event.

A good strategy and mechanism with a noble adaptability are the essential components of Flood Risk Mitigation & Management. These practices are the collective efforts of multi-sectoral agencies working for a unified single goal to Mitigate Flood Risk.

Module Preparation and conducting training is the vital activity of GIDM. The usage of concept, content, lesson, and sessions will be certainly useful for trainees and the program managers to conduct trainings.

I appreciate the efforts of the GIDM team especially Dr. Sandeep K. Pandey, for coming up with the module of Flood Risk Mitigation and Management. I hope this module will benefit trainees, students, researchers, and professionals working in the area of Flood Risk Mitigation and Management. GIDM & NWRWS&K Department have invested their valuable time in preparing the module. GIDM will organize a series of capacity building programs based on this module. I am sure that the concerted efforts in this direction would help in building the Flood Disaster Resilient Society.

(P.K. Taneja)

Director General

November 2020

Gandhinagar

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Abbreviations

ATI	Administrative Training Institute
COR	Commissioner of Relief
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
GIDM	Gujarat Institute of Disaster Management
GIS	Geographic Information System
GSDMA	Gujarat State Disaster Management Authority
HRVA	Hazard Risk and Vulnerability Assessment
UNDRR	United Nation office for Disaster Risk Reduction
JICA	Japan International Cooperation Agency
NDMA	National Disaster Management Authority
NIDM	National Institute of Disaster Management
IMD	India Meteorological Department
CWC	Central Water Commission
SDMP	State Disaster Management Plan
NDRF	National Disaster Response Force
SDRF	State Disaster Response Force
SEOC	State Emergency Operation Centre

Flowchart of the Training Module

“Flood Risk Mitigation & Management”



Training Module Design Brief

Context/ Background

Flood risk management aims to prevent losses and damages by avoiding the exposure of people and property by flooding. This includes lowering the probability of flooding as well as reducing the vulnerability of the society in flood-prone areas. Flood risk management may involve a large number of measures, for example, flood defense measures, flood control measures, spatial planning for lowering the vulnerability of people and property. Here the single-measure management approach is not as effective as multiple/ comprehensive measures. In this context, this training module is designed to cover varied stakeholders who are playing a vital role in Flood Risk Mitigation and Management in State.

Rationale for the course

The module is designed to provide a common platform for experts from State Disaster Management Authority, NWRWS&K, UH&UDD, Rural development, PRI, Agriculture & Revenue department professionals.

In most cases, disaster risk management professionals, involved with the holistic aspect, tend to overlook the specific aspects of flood risks and their mitigations.

Considering the facets and perspectives of flood risks, strategies or measures are formulated for all developments, as development becomes unsustainable if it does not aim for reducing risks from disaster. It becomes essential to provide the requisite knowledge and understanding of flood risks, the possible impacts, mitigation strategies, and future trends.

Target Group

The training is targeted towards professionals involved in Disaster Risk Management, NWRWS&K, UH & UDD, Rural Development, PRI, Agriculture & Revenue Department Professionals. Preferable Group Size: 25-30 participants.

Entry Behaviour

Level of participants: In-service (senior and middle-level officers).

Age Group: Less than 55 years

Educational Qualification: Graduation, preferably with professional qualifications and/or experience

Disaster Experience: Desirable

Key Constraints

The key constraints are presumed to be:

- **Knowledge:** Lack of awareness about the theoretical aspects of flood risk prevention and preparedness aspects.
- **Attitude:** Attitudinal constraints towards training and learning may be a deterrent
- **Time:** As nodal administrative officers with nodal responsibilities a lengthy training may be difficult.
- **Field level experiences:** not always positive, may take precedence over classroom training
- **Transferable Nature of Job:** This may reduce the learning interest.

Objective of the program

The overall objective of the program is to impart adequate knowledge and skill to the trainees to deal with flood risks in their respective spheres of work and formulate strategies/ action plan suitable to prevent risks and build resilience.

Learning Objectives

At the end of the training, participants will be acquainted to:

- i. Disaster risk management and their implementation in the context of Flood
- ii. The nature, extent of threat, and significance of countermeasures required for flood risk reduction and resilience
- iii. Identify the disaster risk management interventions required to deal with flood risks to achieve the goals of prevention, preparedness, response, and mitigation
- iv. The nature of flood risk concerns to achieve the sustainable development goals
- v. The flood disaster risk reduction strategies

Methodology

The training will be conducted in an interactive mode with a judicious mixture of lectures, discussions, demonstrations, experience sharing, field visits, group work, and case study analyses for understanding the major issues in flood risk reduction and resilience.

Teaching Aids

Training will have to be conducted with the help of the following:

- A compendium of background reading materials
- Handouts of presentations or additional material

- **Data Sharing:** All the material to be given at the closure of the program containing the presentations, group exercises, photographs, contact numbers of trainers and co-participants for subsequent updation and networking.

Training Materials and others

The training is designed to be classroom-based. The training materials for classroom teaching like Computers, LCD projectors, Flip charts, markers, etc. would be required in the classroom. For the field trip, maps of the area to be distributed to participants for guidance and risk identification.

Seating Arrangements

The seating arrangements should preferably be four or five circular tables to facilitate group work and allow the trainer to move around the class for interaction.

Language of Instruction

The medium of instruction will be English, Hindi, and Gujarati

Trainers/ Facilitators/ Resource Persons Required

As Flood Risk Mitigation and Management is a multi-disciplinary and cross-cutting issue in disaster risk management, it is difficult for one trainer to deliver all the sessions.

It is necessary to have experts from various fields especially Flood Planning, Forecasting & Warning, Response, Relief, Rehabilitation, etc.

The coordinator's role would be to sum up the inputs given as an outputs for trainees so that they get the best of the knowledge and skills available within and outside the organization.

Expected Outcome

1. Understanding of the flood risk phenomena for better response and preparedness planning
2. Knowledge enhancement and up-gradation of skills for planning and implementation of strategies for flood risk reduction at state, district and local levels.
3. Linking the learning of disaster risk management activities that could lead in the form of efficient response even in the worst-case scenario.
4. Skill development of participants for conducting training sessions on flood risk mitigation and management at the state, district and local levels.

Evaluation & Validation

The course is continually evaluated in terms of summing up the day's inputs by the coordinator, discussing issues raised by participants, and connecting the knowledge inputs to the participants' own experiences.

At the end of the course, a formal evaluation is carried out based on content, objectives, utility, and facilities provided in the program. According to the feedback and coordinator's impressions, the future programs would be designed and conducted.

Pre-Training Assessment

Context & Description

Participants from different organizations have different levels of understanding of disaster risk management and flood risk mitigation concepts. Their orientation towards the subject depends on the nature of duties performed. So in most cases, the understanding of flood disaster risks varies widely across the spectrum. For example, for some trainees, the understanding of the flood risks may be limited to nuances of flood plain development, while participants from administration may focus on instruments of governance like laws, regulations etc. This session is therefore aimed towards assessing the entry behavior of the participants and subsequently getting them on a similar platform so that the objectives of the course are met.

Session objectives

- To assess the expectations of the participants from this course
- To assess the entry behavior of participants
- To make a comparative analysis of the course objectives and participants expectations

Duration - 30 minutes

Methodology

- Expectation Exercise and Discussion
- Q & A Session

Trainers' Note

The session can be divided into two parts viz. the expectation and the entry behavior. To find out participants' expectations from the course, the trainer may distribute sheets of paper for participants to write down the most important expectation. These may then be collected and pasted/pinned to the walls/boards or collated in a composite chart. At the end of the training, a similar exercise can be conducted to see how much of the expectations were met.

- To find out the entry behavior of the participants, a Question & Answer Session can be organized. The coordinator can ask simple questions on the subject & give each trainee 2-5 minutes to ponder and write down the answers. Then proceed to discuss each with the group. If the group is too large, this exercise can be done in pairs.

Session Plan

No	Topic	Duration
1	Expectations & Objectives	15 Mins.
2.	Q & A	15 Mins.

Training/ Performance Aids

Colour paper handouts, Flip charts, Markers, Tag-boards to pin the handouts (walls and scotch tape will suffice if there are no tag-boards).

Technical Session 1: Understanding Disaster Risk

Introduction, Overview & Perspectives

The first technical session would provide an introduction of course to the trainees, after assessing their entry behavior. The course, being interdisciplinary, would use this session for providing an overview of disaster risk management aspects. This session would be divided into two learning units for providing an overview of the subject.

Learning Unit 1.1: Hazards, Vulnerability & Risk: A Conceptual Approach to Disaster Management

Learning Unit 1.2: From DM to DRR: An Overview

The primary objectives of the module would be to:

- Explain the basic concepts of disaster risk management and the impact of human actions on the hazards and risks.
- Trace the evolution of the disaster risk management discipline from the post-disaster response to pre-disaster risk reduction.

Duration: 75 Mins

Methodology

This session has a dual aim of introducing trainees about the training and providing an overview of the subject, as well. The methodology will vary from one learning unit to the other. A formal inauguration may be arranged, followed by informal ice-breakers and discussions. The technical sessions can be conducted subsequently, after a short break for tea, etc. As it is the first day, the technical session would have to be trainer driven, aimed towards facilitating discussions and interaction among the trainees. As far as technical sessions are concerned, they can be conducted in a lecture-cum-discussion mode.

Trainers' Note

The trainer should bear in mind that the first day is crucial to set the tone for the entire program. Therefore, the first day should be designed to acquaint the trainees of the program and make them comfortable in the new surroundings. The following ideas can be considered:

1. **Inaugural session** can be either formal or informal, a formal inauguration would involve inviting high-level dignitaries/experts on the subject. The session would include a formal address from the dignitaries with a brief introduction of the course and participants. In an informal inauguration, the trainer can start directly with a welcome speech followed by the introduction of participants. The introduction session should be conducted innovatively to get everyone to participate so that peer to peer interactions are facilitated. About 30 minutes can be spent on the introduction session. Dividing participants into pairs and getting each to introduce their partners can be used as an ice-breaker.
2. **After the ice-breaker**, 05-10 minutes can be taken to lay down the ground rules of training. This process should involve all participants for better ownership and implementation. This could include:
 - Objectives
 - Session timings
 - Lunch & Tea Breaks
 - Formation of Host Teams and their duties
 - Norms for interactions and discussions during sessions
 - Mobile phone etiquettes
 - Availability of facilities (telephone, internet, etc)
 - Smoking rules/bans etc.
 - Evening engagements (if any)

Learning Unit 1.1: Hazard, Vulnerability & Risk: A Conceptual Approach to Disaster Risk Management

Context/ Background

Humans tend to see Nature, in its pristine form, as an untamed monster or an unregulated entity. We assume, and appropriate totally, the complete ownership over it without giving any due consideration to other living species and their needs. This is an arrogant “Masters of the Universe” mentality, that leads to selfish proprietorship.

We exploit Nature for our own exclusive use and profit, rather than using it for our needs and sustenance. So, ‘development’ becomes an instrument of taming Nature, domesticating it and appropriating it for our own exclusive use, abuse and over-use.

This approach interrupts system function and regulation. To restore and to regulate the system activities; nature goes to extremeness, which may be in the form of catastrophic rainfall, soil moisture loss, high temperature and ground shaking etc. Certainly, it causes loss of life, property damage, and environmental degradation. This whole gamut has various terminology for actual activities taking place i.e. Hazard, Vulnerability, Exposure, Coping Capacity, Disaster Risk etc.

This is the first technical session of the training program. It will broadly cover the basic concepts used in disaster risk management. The session will aim to introduce participants to the concepts and the phases in disaster risk management and also provide a comprehensive recapitulation for the trainees from the disaster risk management field. The aim would also be to underscore the impact of human actions on disaster risks of an area and to explain the need for risk-sensitive development.

Description of the Session

This session will brief about the basic concepts of Disaster Risk Management and its terminologies like Hazard, Vulnerability, Exposure, Coping Capacity, Risk, and the factors governing the risk with the fundamental definitions and terminologies.

Disaster is an actual or imminent event, whether natural or otherwise occurring in any part of the State which causes or threatens to cause all or any of the following:

- 1) Widespread loss or damage to property, both immovable and movable; or
- 2) Widespread loss of human life or injury or illness to human beings; or
- 3) Damage or degradation of the environment;

and any of the effects specified in the (1,2 & 3) above is such as to be beyond the capacity of the affected community to cope up with using its resources and which disrupts the normal functioning of the community.

Disasters are the result of a combination of exposure to hazards, the vulnerability of the affected community, and their capacity to cope-up with the disaster. A disaster is, therefore, the function of hazard, vulnerability and capacity.¹

Let's look an example of disaster: Cyclone Nisarga was the destructive cyclone of the 2020 in Arabian sea. Nisarga made landfall around Mumbai city, the eye of the storm narrowly missed the city, while nearby coastal areas to the south bore the brunt. It was a large storm with violent gusts and storm surges that caused major flooding and left millions of people along the south coast without power. The tens of thousands of people evacuated before the cyclone included 150 patients from a recently-built Covid-19 field hospital. Nisarga comes barely two weeks after Cyclone Amphan struck, devastating parts of Kolkata (formerly Calcutta) on the east coast. More than 100 people were killed in the Indian states of West Bengal and Orissa, as well as neighboring Bangladesh.

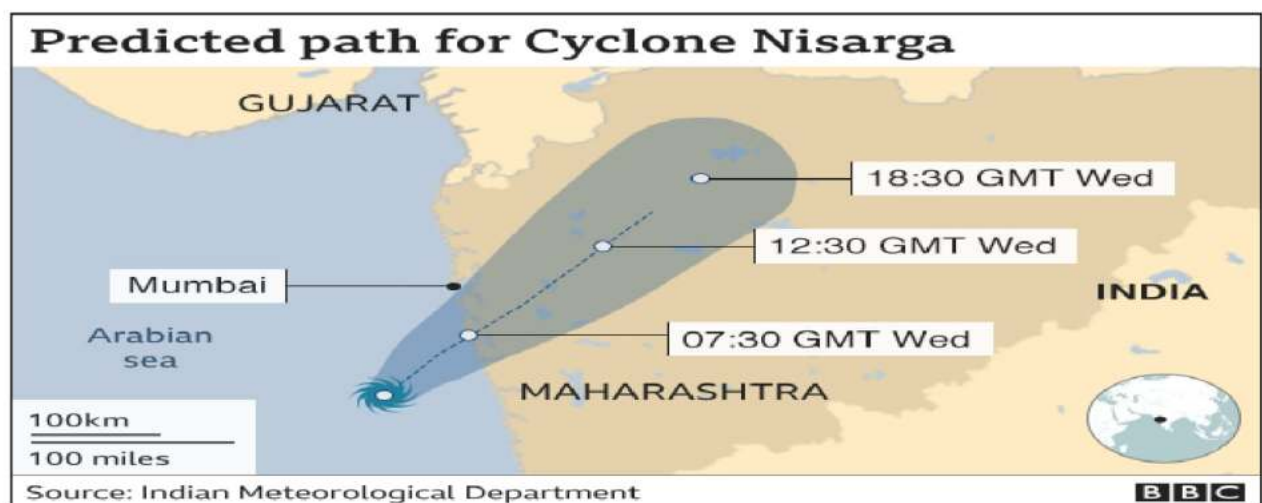


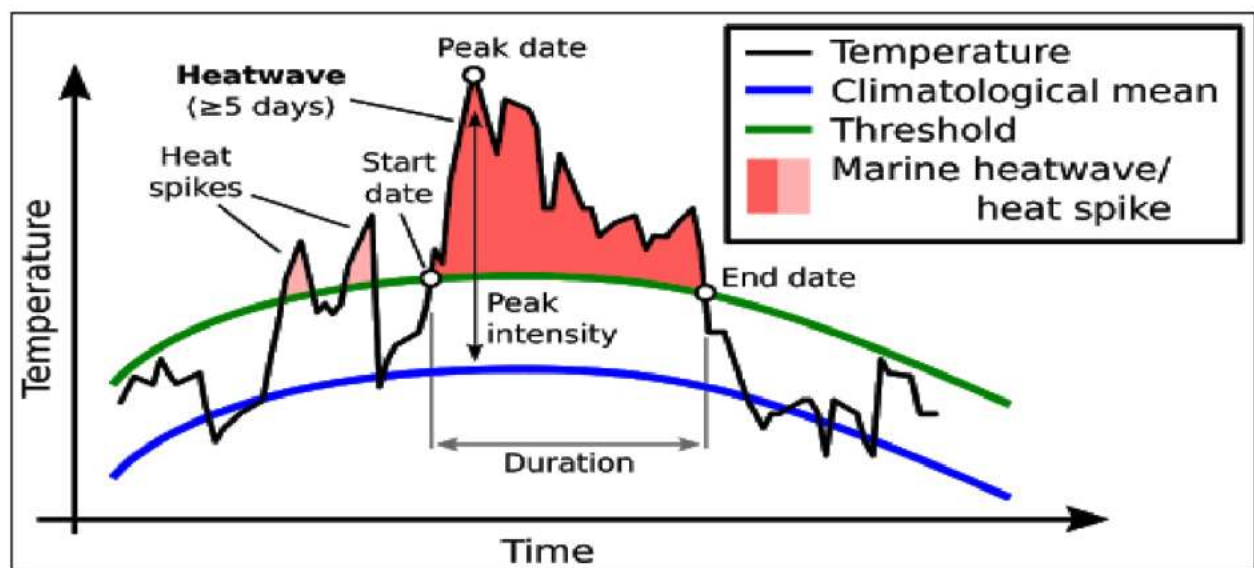
Figure 1: Predicted path for Cyclone Nisarga 2020

In 2019, Vadodara city received 424 mm rainfall pouring within a very short span of six hours from 2 pm to 8 pm on 31st July 2019. The floodwaters inundated the city Vadodara and washed away villages, damaged/destroyed houses caused loss of life and extensive property damage.

Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards arise from a variety of geological, meteorological, hydrological, oceanic, biological, and technological sources, sometimes acting in combination. Therefore, these are classified generically as geological, hydro-meteorological, or technological hazards. Hazards aggravated by

degrading environments due to human actions are termed socio-natural hazards. Each hazard is characterized by its location, intensity or magnitude, frequency, and probability. Biological hazards are also defined by their infectious nature or other characteristics of the pathogen such as dose-response, incubation period, case fatality rate, and estimation of the pathogen for transmission².

Every year major cities of Gujarat face heatwave stress, Heatwaves typically occur between March to June, and in some rare cases even extend till July. Extreme heat leads to heat exhaustion and heat stroke, it can exacerbate chronic cardiovascular and respiratory diseases, and make daily tasks and work outdoors harmful or deadly.



Source: <https://www.civildaily.com>

Figure 2: Sketch Diagram of Heatwave Hazard Threshold

UNDRR has published on comprehensive Document on hazards in the name of Hazard report. In this document clusters of hazards notified as under:

1. Meteorological and hydrological hazards
2. Extraterrestrial hazards
3. Geo-hazards
4. Environmental hazards
5. Chemical hazards
6. Biological hazards
7. Technological hazards
8. Societal hazards

Exposure is the situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific vulnerability and capacity of the exposed elements to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest³.

If a hazard occurs in an area of no exposure, then there is no risk. Take the example of typhoons (tropical cyclones that occur in the Pacific Ocean). In October 2013 a Category 5 super typhoon (known as Lekima) hit the North West Pacific Ocean. Its winds reached peaks of around 240 kilometers per hour, but caused no impact on people or assets. In November 2013 another Category 5 Super Typhoon Haiyan (Yolanda) hit the region, with winds peaking at 315 kilometres per hour. Haiyan affected 11 million people, causing more than 6000 casualties and the loss of more than 1.5 billion US dollars. The difference in impact was because there were no people or property in the path of Lekima; in other words, there was no exposure.

- *Measures of exposure can include the number of people or types of assets in an area.*
- *Let's say that there is an imminent danger of a forest fire, in that case the exposure would be of the forest area and the flora and fauna of the area!*
- *To put it simply, if you feel that you can be affected by a hazard, you are exposed!*



Figure 3: A Snap view of Hazard exposure

Vulnerability is the condition determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards. Vulnerability is the human dimension of disasters and is the result of the range of economic, social, cultural, institutional, political, and psychological factors that shape people's lives and the environment that they live in. Many of the underlying drivers

of vulnerability, including poorly managed urban development are increasing and resulting in vulnerability increase in many countries and regions of the world.⁴

- If you build your house in an area which is prone to flood or earthquake, you are **vulnerable**.
- Let's say that you have built your house no matter what, but if you have not taken any measure to deal with it, then you are **more vulnerable**!



Figure 4: A Snap view of Hazard Vulnerability

Capacity is the combination of all the strengths, attributes, and resources available within an organization, community, or society to manage and reduce disaster risks and strengthen resilience. Like vulnerability, capacity has physical, social, economic, or environmental connotations and may include infrastructure and physical means, institutions, societal coping abilities, as well as human knowledge, skills, and collective attributes such as social relationships, leadership, and management.

Example: As we know that more than 66% of the agriculture area in Gujarat state is Arid and Semi-Arid nature. to combat the drought situation Gujarat state has developed the Sardar Sarovar Project and laid more than 450 km long canal system. Moreover state has promoted drip irrigation artificial mulching and other activities that may cope-up with the water scarcity situation.

Resilience is the ability of a system, community or society exposed to hazards - to resist, absorb, accommodate, adapt, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

Example:

In terms of urban areas resilience means better organizing urban areas through the combination of different disciplines such as architecture, design, **eco-design**, sustainable construction, urban planning, health planning or energy, waste, traffic, and parking management. The union of these systems makes it possible to develop resilient cities – cities that can better handle natural and human-made disasters, protect human life, absorb the impact of economic, environmental and social hazards and promote well-being and inclusive and sustainable growth.

Disaster Risk (DR) is, therefore, the potential disaster loss, in lives, health status, livelihoods, assets, and services, which could occur to a particular community or a society over some specified future period. The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies, and improved coping capacities to lessen the adverse impacts of hazards and the possibility of disaster is disaster risk.

Disaster Risk Reduction (DRR) is aimed at preventing new, reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. Disaster risk reduction strategies and policies define goals and objectives across different timescales with concrete targets, indicators and time frames. In line with the Sendai Framework for Disaster Risk Reduction 2015-2030, these should be aimed at preventing the creation of disaster risk, the reduction of existing risk, and strengthening of economic, social, health, and environmental resilience.

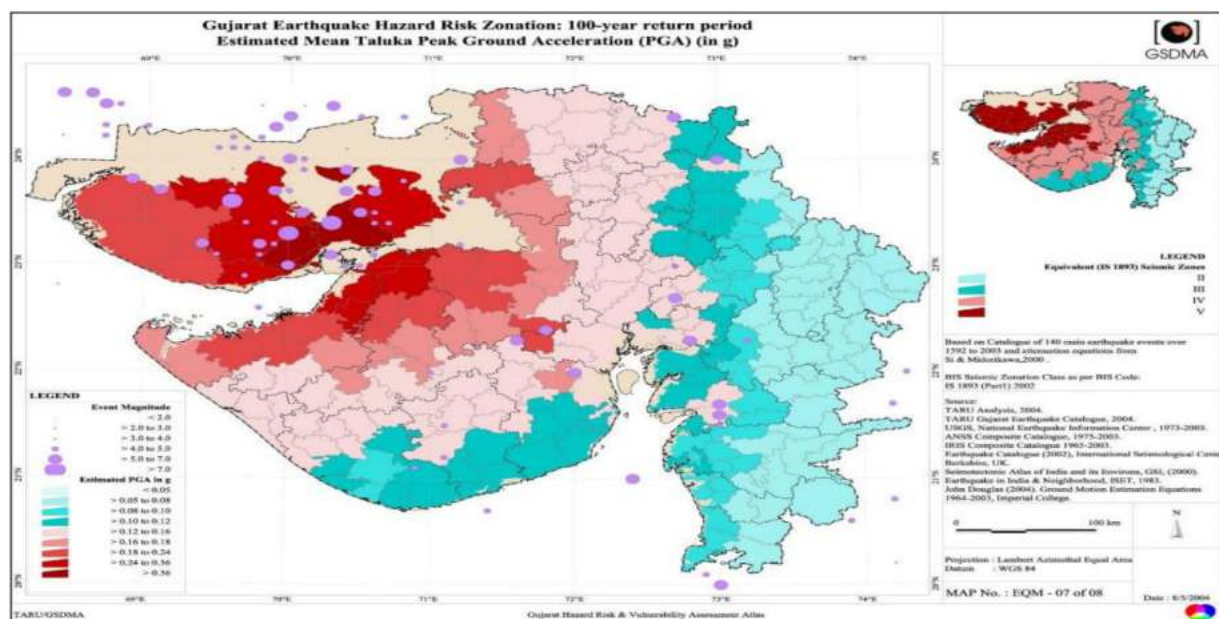
Hazard Risk Vulnerability Assessment (HRVA) of Gujarat:

Earthquake: As per Indian Seismic Zone Map, the Gujarat region lies in three zones- Zone III, IV, and V. Kachchh region (about 300km x 300km) lies in zone V where earthquakes of magnitude 8 can be expected. A belt of about 60-70 km width around this zone covering areas of North Saurashtra and areas bordering Eastern part of Kachchh lie in zone IV where intensity eight can be expected mainly due to earthquakes in Kachchh and some local earthquakes along North Kathiawar Fault in Northern Saurashtra. The rest of Gujarat lies in zone III where intensity seven earthquakes can be expected due to moderate local earthquakes or strong Kachchh earthquakes.

All of Kachchh, almost the entire coastline of northern Saurashtra that adjoins Kachchh and a small area in Patan district fall into the very severe intensity zone over a 100-year return period.

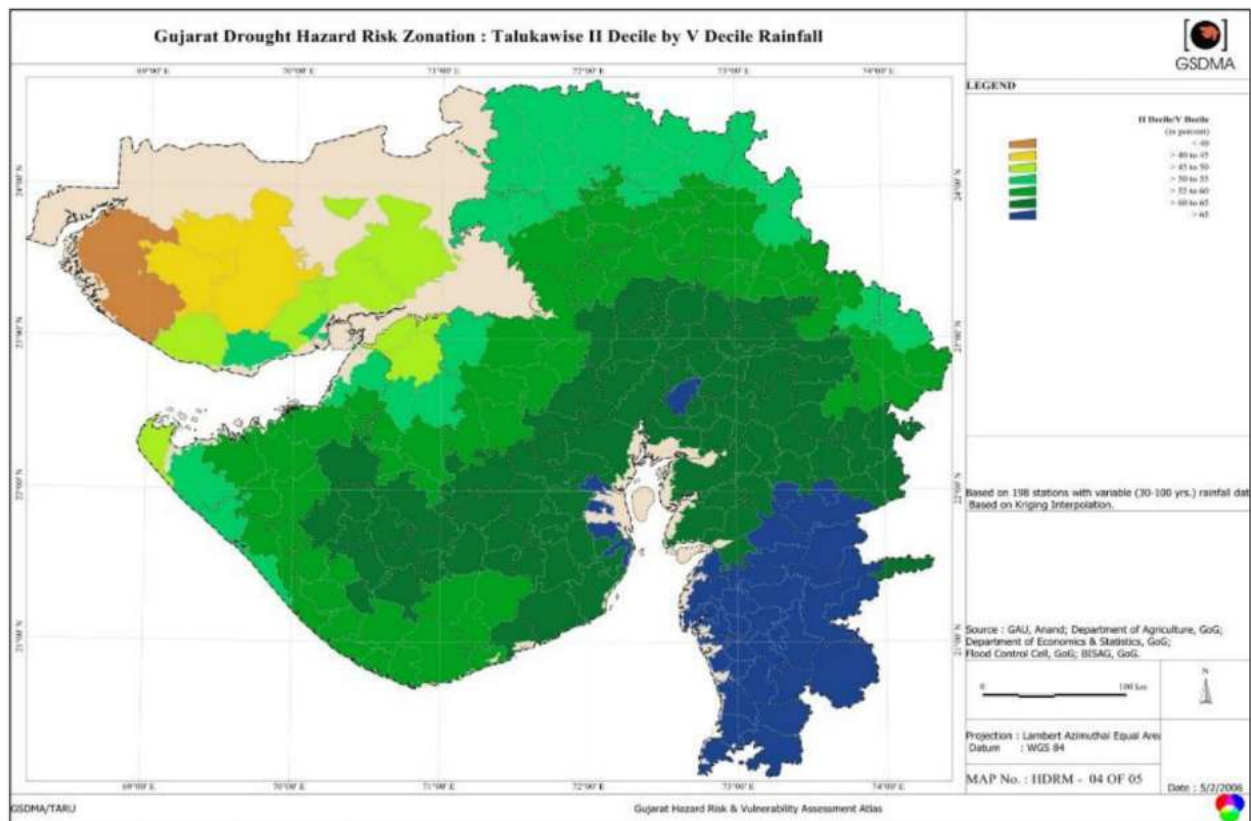
The cities of Ahmedabad, Bharuch, Rajkot, and Bhavnagar fall into the severe intensity zone, while Bhuj and Jamnagar fall in the very severe intensity zone over this time frame.

Drought: Daily temperature of the State ranges from a minimum 13°C to 27°C in winter and from 27°C to 41°C in the summer. The South-West winds mostly bring rain between June to September and approximately 90 to 95% of precipitation is registered in these three months. From the North-West areas to South Gujarat areas, the rainfall varies from 300 mm to 2000 mm per annum. In Gujarat, 60% of rainfall is uncertain, unprecedented, and unequal wherein the regions of Saurashtra Kutch and North Gujarat face scarcity every third year. Since 1900, the state has faced a scarcity of water and food for almost 30 times. Gujarat is one of the chronic drought-prone states of India, with an average annual rainfall of about only 700 mm with more than half of the Talukas of Gujarat receiving rainfall within the range of 200-400 mm. Substantial portions of the State are arid to semiarid. With large parts of North Gujarat and Saurashtra having no source of alternate irrigation, groundwater exploitation is leading to increased threats of droughts. Falling water tables have added stress on crops and water supplies.



Source: GSDMP, 2016-17, Part-I

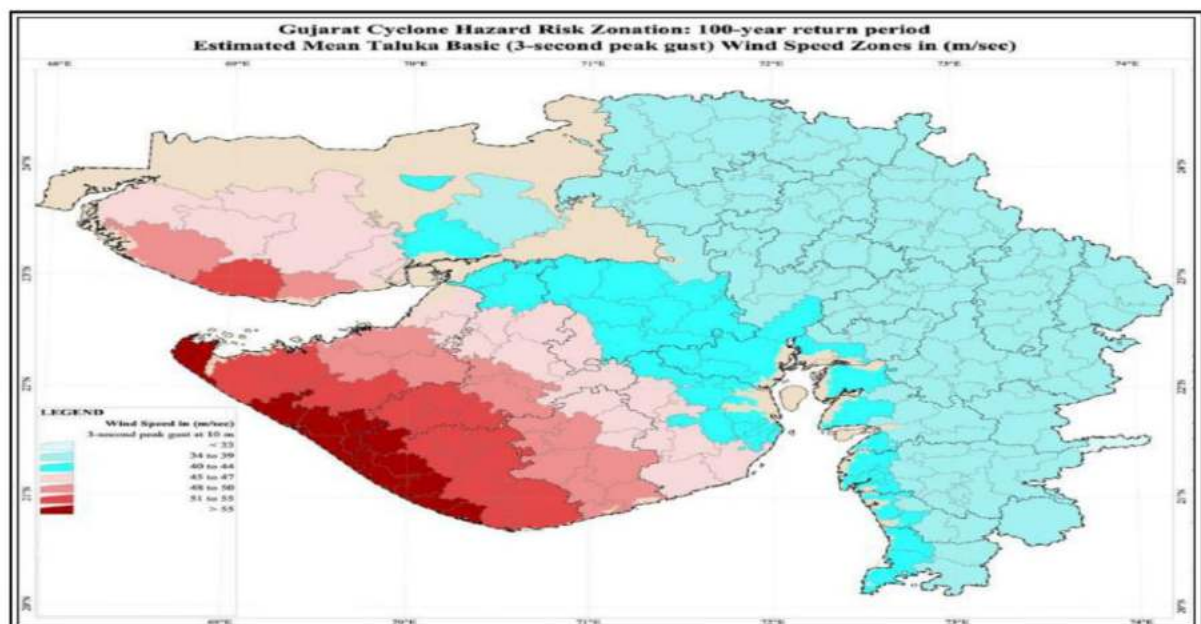
Figure 5: Gujarat Earthquake Hazard Risk Zonation



Source: GSDMP, 2016-17, Part-I

Figure 6: Gujarat Drought Hazard Risk Zonation

Cyclone: Gujarat falls in the region of tropical cyclone. With the longest coastline of ~1600 km in the country, it is highly vulnerable to cyclone and its associated hazards such as floods, storm surges, etc. Most of the cyclones affecting the state are generated in the Arabian Sea. They move North-East and hit the coast particularly the Southern Kutch, Southern Saurashtra, and the



Source: GSDMP, 2016-17, Part-I

Figure 7: Gujarat Cyclone Hazard Risk Zonation

Western part of Gujarat. Two cyclonic storm seasons are experienced in Gujarat: May to June (advancing southwest monsoon) and September to November (retreating monsoon).

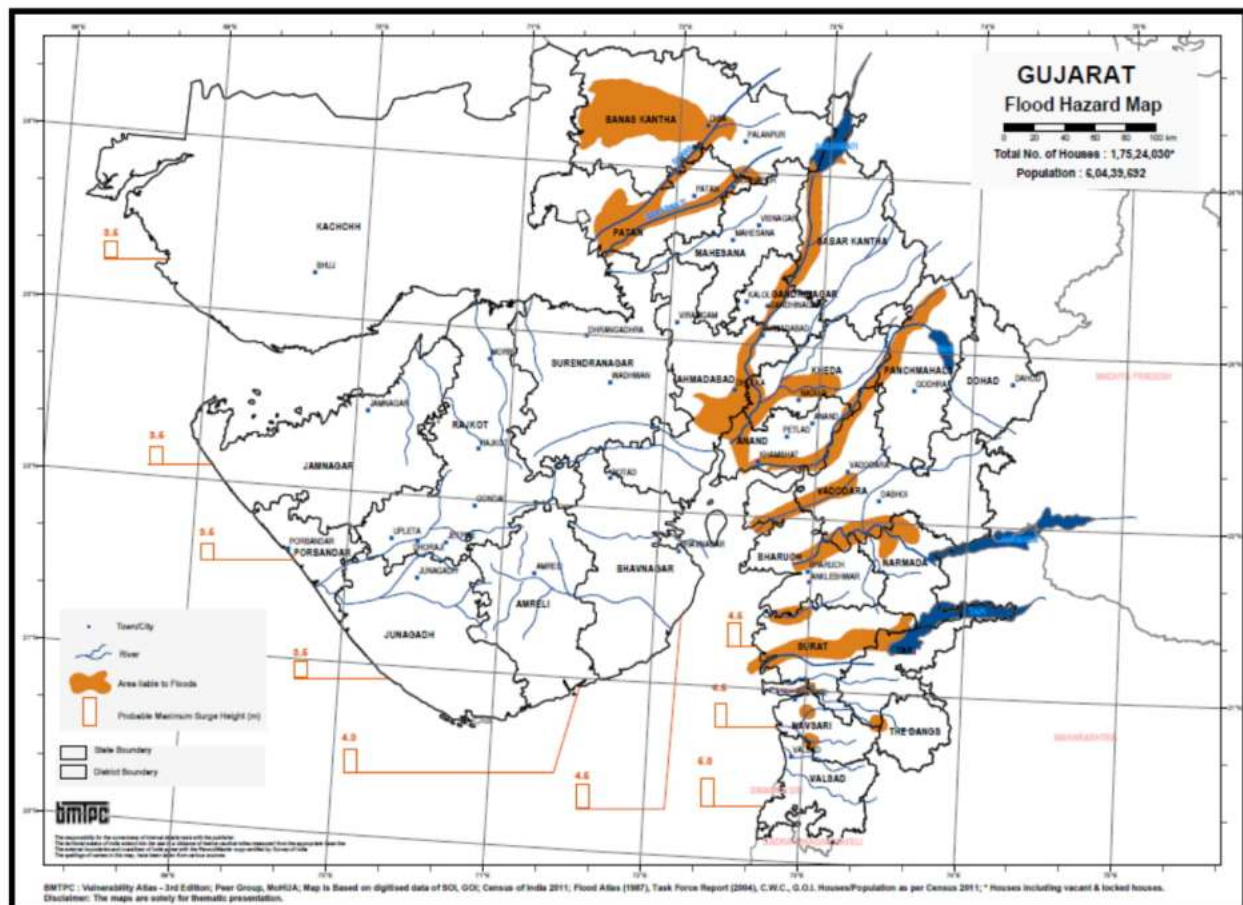
Over 120 cyclones originating in the Arabian Sea had passed through Gujarat over 100 years. Figure shows a maximum wind speed class of more than 55 m/sec along the Saurashtra coast, specifically in Porbandar, Jamnagar and Junagadh districts, which are exposed to high intensity cyclonic and storm impact. The 51 to 55 m/sec class extends further inland to cover much of Jamnagar, part of Rajkot, Junagadh and Kutch districts. The 48 to 50 m/sec class extends to most of Rajkot, part of Amreli and Jamnagar districts including Jamnagar, Rajkot cities, and parts of Kutch. The 45 to 47 m/sec class covers much of Saurashtra and all of Kutch. This is followed by the 40 to 44 m/sec class that gets its swathe from Kutch through northern Saurashtra to the coast of Gulf of Khambhat and southern Gujarat. The rest of the State falls into the 34 to 39 m/sec class.

Flood: The climatology of Gujarat is influenced by the Arabian Sea in the West and three hill ranges along its Eastern border. A long coastline makes parts of arid Saurashtra, and Kutch occasionally experiences very high rainfall. These occasional heavy rainstorms are responsible for most of the floods in the State. While the Northern part of the State is mostly arid and semi-arid, the Southern part is humid to sub-humid. Extremes of climate, be it rainfall or temperatures, are quite common in this region. All major rivers in the State pass through a wide stretch of the very flat terrain before reaching the sea. These flat lowlands of lower river basins are prone to flooding. Cities like Ahmedabad, Surat and Bharuch are located on the flat alluvial plains of large rivers.

Catastrophic runoff resulted from heavy rainfall caused flash floods in the small river basin of Saurashtra and Kutch because of their fairly impervious catchments (rocky or black cotton soils) and steep sloping of upper catchments.

The flood-prone river sections were identified from settlement level analysis. Flood prone river sections in Saurashtra extend to the upper basins due to the presence of dams that have to resort to emergency discharge during heavy rainstorms. Even small valleys in Saurashtra are used for agriculture. Hence, flooding in these zones impacts both residents and settlements.

The majority of the area of Gujarat is flood-prone, irrespective of the size of the catchment. The flood risk in Saurashtra is lower than that of the South Gujarat plains. The relatively flat plains in the lower basic areas with hilly catchments in upper parts of South Gujarat accentuate flood risks. Few villages in the North Gujarat are flood-prone too.



Source: BMTPC

Figure 8: Flood Hazard Map Gujarat (BMTPC, 2019)

Tsunami: Gujarat is prone to tsunami risk due to its long coastline and probability of occurrence of near and offshore submarine earthquakes in the Arabian Sea. Makran Subduction Zone (MSZ) -South West of

Karachi is an active fault area that may cause a high magnitude earthquake under the sea leading to a tsunami. In the past, Kandla coast was hit by a Tsunami of 12 meters height in 1945, due to an earthquake in the Makran fault line. Tsunami prone areas in the State include coastal villages of Kutch, Jamnagar, Rajkot, Porbandar, Bhavnagar, Anand, Ahmedabad, Bharuch, Surat, Navsari and Valsad districts. Fire, Industrial & Chemical Accidents, Heatwave, Epidemic, Stampede etc. are also frequent in Gujarat.

An overall Composite Risk Index for all hazards on a taluka-wise basis has been estimated for prioritization of overall investments, disaster mitigation, and related development interventions. The risk index has been computed by stratifying annualized risk estimates by two decile classes to generate a five-point scale (Very High, High, Moderate, Low, and Very Low). Composite Risk Index

The Disaster Risk Management Cycle (DRM Cycle) identifies the activities to be undertaken before, during or after a disaster. Disaster risk management is a continuous activity, which needs to be dealt comprehensively. Thus the cycle consists of activities in the pre-disaster, during disaster and post-disaster phase. **Prevention** means the measures to avoid the occurrence of a disaster. **Mitigation** is aimed at reducing the impact or effect of disaster. **Preparedness** means the state of readiness which enables stakeholders to mobilize, organize, and provide relief to deal with an impending or actual disaster or the effect of a disaster. **Response** means measures taken during or immediately after a declaration of disaster to diminish or alleviate any suffering, pain, injury, distress or hardship caused on account of the disaster. **Recovery** is the action taken by the community, all the government and the non-government agencies to reset the condition after the disaster and to minimize the vulnerability of the same kind of disaster in future. The use of recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems and into the revitalization of livelihoods, economies and the environment defines the concept of “Build Back Better”.

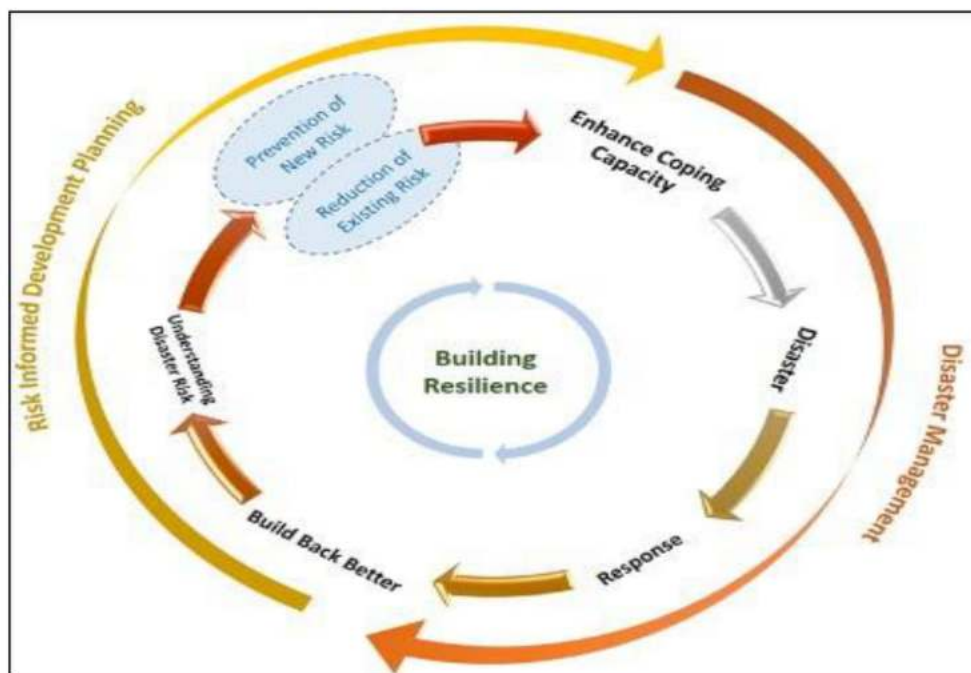


Figure 11: Disaster Risk Management Cycle

Learning Unit 1.2: From DM to DRM- An Overview of Risk Management

Background

This session will broadly cover the basics of disaster risk management and its process of evolution as a discipline. The session would aim to provide participants an overview of the growth of disaster risk management as a discipline of discourse. It will trace the development of the subject from ancient to modern, with emphasis on the paradigm shift in the 1990s. The aim is to trace the history of disaster risk management and link it to the issue of sustainable development.

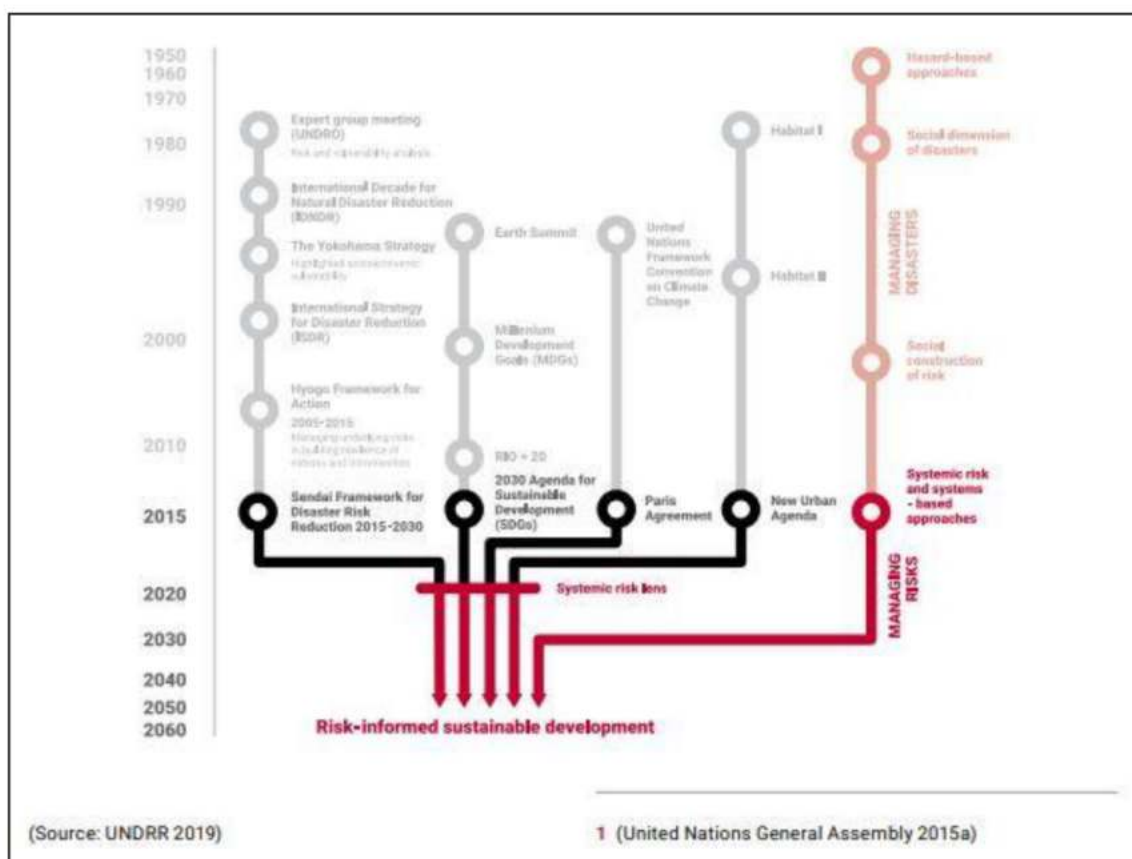


Figure 12: Evolution of Disaster Risk Management

Description of the Session

Coping with disasters has been a way of life for the human civilization. The Indus Valley Civilization, one of the greatest urban civilizations is thought to have been destroyed by a calamity. With the evolution of society especially in the post- Industrial Revolution era, the magnitude and impact of disasters increased exponentially. Globally, between 2005-2015, over 7 lakhs people have lost their lives, over 1.4 million have been injured and approximately 23 million have been made homeless as a result of disasters. Overall, more

than 1.5 billion people have been affected by disasters in various ways, with women, children, and people in vulnerable situations being disproportionately affected. The total economic loss was more than \$1.3 trillion and between 2008 and 2012, 144 million people were displaced by disasters (UNDRR). This session aims at providing a general overview of the process and instruments of disaster management.

Notwithstanding the continuous increase in the frequency and magnitude of disasters, the management remained reactive over the years. Disaster events continued to be considered as interruptions or aberration in the development process, to be managed through relief disbursement and reconstruction assistance. Globally, a paradigm shift in the approach to disaster management from relief and rehabilitation to prevention and mitigation and a holistic and comprehensive framework, took place when the United Nations observed the 1990s as the **International Decade for Natural Disaster Reduction (IDNDR)**. The objective of the IDNDR was to “reduce, through concerted international action, especially in developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters.” In 1994 the **Yokohama Strategy** and Plan of Action for a Safer World was adopted at the World Conference on Natural Disasters. The strategy called for accelerated implementation of a Plan of Action based on evolving a global culture of prevention, an integrated approach to disaster reduction, unequivocal political commitment for vulnerability reduction, community participation, improved risk assessment, broader monitoring, and communication of forecasts and early warnings.

In 1999, the United Nations General Assembly Resolution adopted the **International Strategy for Disaster Reduction (ISDR)** and created the Secretariat of the ISDR (UNISDR currently UNDRR). The International Strategy for Disaster Reduction (ISDR) is a multi-disciplinary and multi-stakeholder platform to enable societies to increase their resilience to natural, technological and environmental disasters and to reduce associated environmental, human, economic, and social losses. A range of United Nations organizations and international partners participated in cooperation with Governments and civil society organizations. In adapting ISDR, the United Nations General Assembly (Res/54/219) endorsed the establishment of an institutional framework for its implementation consisting of the Inter-Agency Task Force on Disaster Reduction (IATF/DR) and the inter-agency secretariat (ISDR secretariat). The main functions of the secretariat are policy coordination, advocacy, and information management, at the international and regional levels, to ensure synergy between disaster reduction strategies and those in the socio-economic and humanitarian fields.

In 2003 and 2004, the UNISDR carried out a review of the Yokohama Strategy and Plan of Action for a Safer World. The review formed the basis of the **Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA)** which was adopted by the World Conference on Disaster Reduction held in Jan. 2005 and subsequently endorsed by the General Assembly of the United Nations.

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) is the successor instrument to the HFA. It was adopted at the Third UN World Conference in Sendai, Japan, on March 18, 2015. The Sendai Framework is built on elements which ensure continuity with the work done by States and other stakeholders under the HFA and introduces several innovations as called for during the consultations and negotiations. Many commentators have identified the most significant shifts as a strong emphasis on disaster risk management, besides disaster management. The definition of seven global targets, the reduction of disaster risk as an expected outcome, a goal focused on preventing new risk, reducing existing risk and strengthening resilience, as well as a set of guiding principles, including the primary responsibility of states to prevent and reduce disaster risk, all-of-society & State institutions engagement. Also, the scope of disaster risk reduction has been broadened significantly to focus on both natural and man-made hazards and related environmental, technological, biological hazards and risks. Health resilience is strongly promoted throughout.

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks:

- 1) Understanding disaster risk;
- 2) Strengthening disaster risk governance to manage disaster risk;
- 3) Investing in disaster risk reduction for resilience;
- 4) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation, and reconstruction.

It aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods, health, economic, physical, social, cultural and environmental assets of persons, businesses, communities, and countries over the next 15 years. The chart for SFDRR is as under:

Targets

Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015

Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015

Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030

Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030

Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020

Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030

Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030

Priorities for Action

There is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas.

Priority 1

Understanding disaster risk

Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment

Priority 2

Strengthening disaster risk governance to manage disaster risk

Disaster risk governance at the national, regional and global levels is vital to the management of disaster risk reduction in all sectors and ensuring the coherence of national and local frameworks of laws, regulations and public policies that, by defining roles and responsibilities, guide, encourage and incentivize the public and private sectors to take action and address disaster risk

Priority 3

Investing in disaster risk reduction for resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses and ensure effective recovery and rehabilitation

Priority 4

Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction

Experience indicates that disaster preparedness needs to be strengthened for more effective response and ensure capacities are in place for effective recovery. Disasters have also demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of the disaster, is an opportunity to «Build Back Better» through integrating disaster risk reduction measures. Women and persons with disabilities should publicly lead and promote gender-equitable and universally accessible approaches during the response and reconstruction phases

Scope and purpose

The present framework will apply to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks.

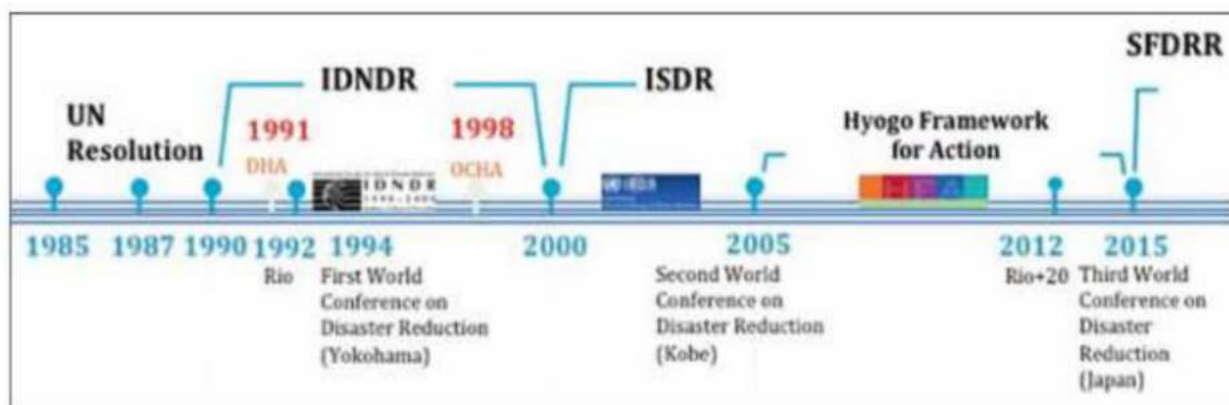
It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors

Expected outcome

The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries

Goal

Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus **strengthen resilience**



Source: UNDRR

Figure 13: Sketch view of Successive International Frameworks in Disaster Risk Management

Disaster and Development

Disasters and development are closely linked. Disasters can destroy development initiatives and create development opportunities. Development schemes can both increase and decrease vulnerability.

In the traditional approach to disasters, the attitude was that the disasters, especially natural ones, were an act of God and so as were beyond human control; accepting death and damage to property was part of the costs. With such an attitude, most development plans were designed without consideration for the effect disasters would have on community plans and vice-versa. When a disaster did occur, the response was directed at meeting emergency needs and cleaning up.

In the current approach, it has been realized that much more is needed and could be done to reduce the severity of hazards and disasters. A growing body of knowledge on the relationships between disasters and development indicates four basic themes as follows:

- 1) Disasters set back development programming, destroying years of development initiatives.
- 2) Rebuilding after a disaster provides significant opportunities to initiate development programs.
- 3) Development programs can increase an area's susceptibility to disasters
- 4) Development programs can be designed to decrease the susceptibility to disasters and their negative consequences.

Thus, policymakers cannot ignore the relationship between disaster and development. Projects are thus being designed to include disaster recovery programs and with long term development needs in mind.

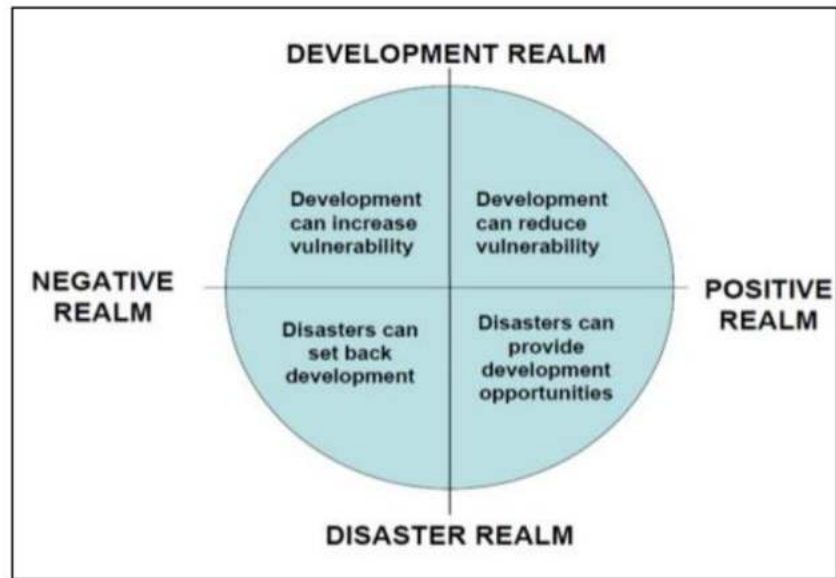


Figure 14: Sketch view of the Disaster and Development Relationship

Technical Session 2: Understanding Flood Risk

Overview of Session:

In this session, the focus would be on flood overview, definition, types, characteristics, effects, vulnerability and risks of flood in India/Gujarat

Objectives:

By the end of the session, participants would acquaint to:

1. Flood Hazard,
2. Flood Vulnerability Factors
3. Flood Risks in Gujarat

Learning Units:

- LU 2.1 Flood Overview, definition and types
- LU 2.2 Causes of Flood, Factors Associated with Flood
- LU 2.3 Flood Damage Aggravation Factors
- LU 2.4 Anthropogenic Interventions & Losses
- LU 2.5 Flood Hazard Assessment
- LU 2.6 Flood Vulnerability and Flood Affected Areas in India & Gujarat
- LU 2.7 Flood Vulnerability Assessment
- LU 2.8 Flood Risk Assessment

Duration: 150 Min.

Suggested Methods:

Presentation, discussion, and interactive learning

How to Conduct:

Ask the participants to be in groups of four for the group activity

1. Ask them to select any one type of Flood

2. Ask them what are the factors involved in flood situation or how it affects the common man?
3. Each group should make a brief presentation on the discussion
4. Build all the responses into the framework
5. Presentation

Learning Unit 2.1: Flood Overview, Definitions

Types of Flood & Flood Categories

Flood Overview:

Flood is the overflow of water from their normal confinements. The flood hazard takes place due to precipitation, storm surges from tropical storms, dam bursts, and burst of water canals. Floods are harmful to human settlement in terms of lives lost, property damage, and crop loss.

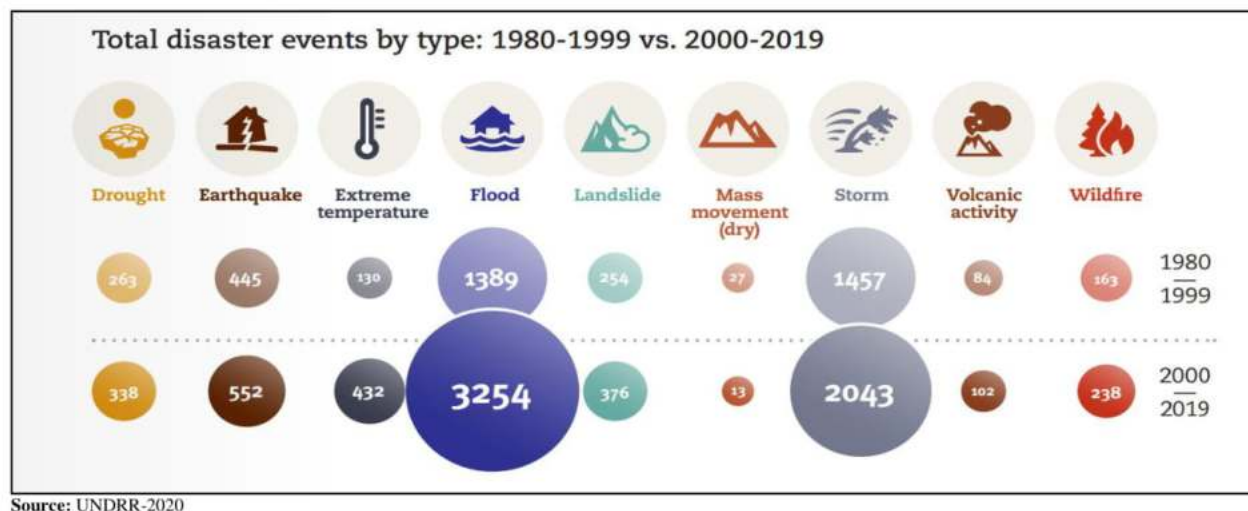


Figure 15: Total Disaster Events by Type: 1980 - 2019

The average annual loss from floods in India is estimated to be US\$ 7.4 billion⁵. Apart from devastating results, floods can provide benefits in maintaining most river ecosystems, alluvial soil to enhance fertility, groundwater recharge, water for crop irrigation, fisheries, and contribute seasonal water supplies to support life.

Definition of Floods:

Flood is a general and temporary condition of inundation from different sources of incidence. A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from the unusual and rapid accumulation or runoff of surface waters from any source⁶.

Major types of flood maybe:

1. Flash Flood
2. River Flood
3. Coastal Flood
4. Urban Flood

Types of Floods

Flash floods – Flood that occurs within six hours of heavy rainfall called flash flood. Flash floods take from minutes to hours in development. It causes after a dam, levee failure, sudden release of water by ice or debris jam. The meteorological condition of a flash flood is towering cumulus clouds, severe thunderstorms, tropical cyclones, or the passage of cold-water fronts, torrential downpour.

Devastating results of flash floods exhibit at steep slopes where surface runoff is high, water flows through narrow canyons, and where severe rainstorms are likely to have happened.

River Floods –River floods are the result of the high discharge of rivers due to heavy rainfall or other reasons. It generally builds up slowly, it takes days and weeks in development and receding. Low lying areas get affected first. It is due to excessive downpour in their catchment areas where flood takes place in river systems with tributaries. This type of flood is predictable. Its onset, possible areas inundated and possible risks and damage can be calculated.

Coastal Floods – Coastal floods are the result of tropical cyclones or high wind speed. Wind-induced storm surge inundates land with salt water. The magnitude and extension depend on the coastal topography, storm surge conditions, and broader bathymetry of the coastal area. It causes loss of property, life. The salt ingress causes soil fertility loss.

Urban Floods/Pluvial Flooding – Urban flooding is caused mostly by rain that falls on impervious surfaces and overwhelms local stormwater drainage capacity. Each of these components—heavy precipitation (which is expected to become more frequent due to climate change), increased urbanization, and insufficient or outdated stormwater infrastructure—presents a challenge in and of itself.

It is a frequent phenomenon. Almost every city is vulnerable to urban flooding in one way or another, here urban dwellers are at high risk. As a result, water runs off on the concrete structures, sometimes known as *pluvial flooding* or *urban flooding*. The intensity of urban floods becomes higher with prolonged rainfall. The probability of urban flooding is expected to further increase with a changing climate.⁴

Flood Categories:

The **Central Water Commission** has categorized various flood situations for monitoring the floods in the country through its flood forecasting network. It has been categorized into *four* namely Normal, Above Normal, Severe, and Extreme depending upon the river water level concerning warning level, danger level, and highest flood level.

Normal Flood:

The river is said to be in a “NORMAL FLOOD” situation at any flood prediction sites when the water level of the river is below the warning level.

Above Normal Flood:

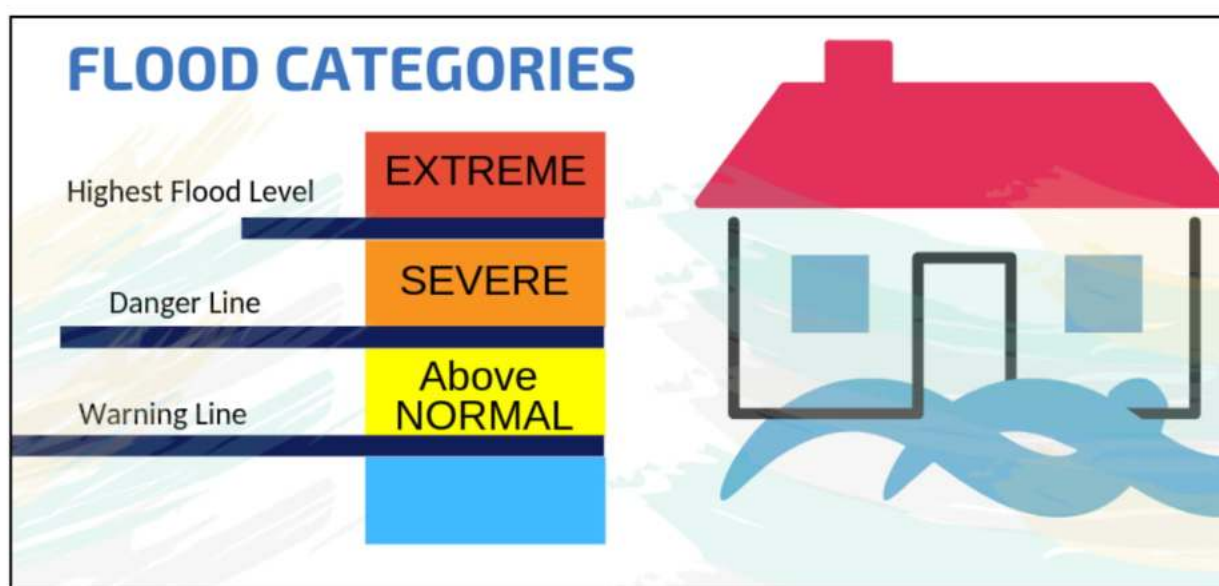
If the water level of the river at the flood prediction site touches or crosses its Warning level, but remains below the Danger Level of the site then the flood situation is called the “ABOVE NORMAL” situation. **Yellow color** has been assigned to this category.

Severe Flood:

If the water level of the river at the predicting site touches or crosses Danger Level but below the Highest Flood Level of the anticipation, then the flood situation is called the “SEVERE FLOOD” situation. **Orange colour** has been assigned to this category. In “Severe Flood Situations” a special “Orange Bulletin” is being issued by the Central Water Commission to the user's agencies which contains the “special flood message” related to the severe flood and is updated every three hours.

Extreme Flood:

The flood situation is said to be “EXTREME” when the water level of the river touches or crosses the “HIGHEST FLOOD LEVEL” recorded at any anticipation site so far. Red colour has been assigned to this category. In “Extreme Flood Situations” a special “**Red Bulletin**” is being issued by the Central Water Commission to the user's agencies which contains the “special flood message” related to the extreme flood and is updated every hour.⁷



Source: Central Water Commission

Figure 16: Sketch Diagram of Flood Categories

Learning Unit 2.2: Causes and Factors Associated with Flood

Causes of Floods

The most prominent cause of floods is extreme rainfall. Rain may be seasonally occurring over wide areas or may form localized storms, which produces the highest intensity rainfall.

2. The second cause of the flood is attributed to atmospheric and oceanic processes such as the El- Niño Southern Oscillation (ENSO) or strong jet streams.

3. Global warming is causing more floods. As temperature rises, the air holds more moisture. Rainfall becomes less frequent, creating devoid of moisture. At some point, the sky releases its moisture in a torrential downpour, which creates floods. Instead of soaking into the ground, the water runs on the hard-packed earth surface.

4. Climate change causes floods by shifting the pattern of the jet stream. The Arctic is warming faster than the temperate zones that change the air pressure and turns the jet stream. When it plunges south, it picks up tropical moisture from the Gulf of Mexico and dumps it on Peru. A higher temperature means less snow and more rain.

5. Major contributor to floods in hilly areas is melting snow.

Factors associated with Floods:

Prominent factors of flooding are:

1. Rainfall Intensity

The intensity of rainfall is a measure of the amount of rain that falls over a period of time. The intensity of rain is measured in the height of the water layer covering the ground in a definite period. It depends on the local circumstances.

2. Rainfall Duration

Period during which continuous rain is observed, or occurs, at a given point or within a given area.

Table 1: Average Annual precipitation in India

Average annual Precipitation	4000 BCM
Avg. precipitation during Monsoon (Jun-Sept)	3000 BCM
Natural Runoff	1986.5 BCM
Estimated utilizable surface water resources	690 BCM
Total utilizable ground water resources	433 BCM
Total annual utilizable water resources	1123 BCM
Per capita water availability	1720.29 cum

The average annual precipitation is estimated as 4,000 billion cubic meters (b.cu.m) of which monsoon rainfall from June to September itself is around 3000 b.cu.m. The average annual runoff as per the estimate of the Central Water Commission is 1869 b.cu.m. The aerial distribution of the water resources in the country is highly uneven. Though the present national per capita annual availability is assessed to be about 2,200 cu.m. The average availability in the Brahmaputra basin is as high as 18,400 cu.m while it is as low as 380 cu.m in some of the east-flowing rivers of Tamil Nadu⁸.

3. Topography

Topography is the shape and features of land surfaces. This includes changes in the surface such as mountains and valleys as well as features such as rivers and roads. Topography is closely linked to the practice of surveying, which is the practice of determining and recording the position of points concerning one another. It includes slope, aspect, gradient, etc. It has a high influence on flood.

4. Soil Conditions

Soil is a heterogeneous mixture of mineral matter, organic matter, soil water, soil air, and biotic components. Soil aggregates determines the soil condition that is responsible for the infiltration rate and surface runoff. Soil compactness enhance runoff and contribute to flood-like situation.

5. Ground Cover

Ground cover is the soil surface covered by vegetation, functional role of ground cover may be divided into two major related categories: bio-protection and bioconstruction. Plant cover protects the soil against erosion by reducing water runoff and by increasing water infiltration into the soil matrix.

Plants shelter fix the soil with their roots reduce the energy of raindrops with their canopy. Vegetation can act as a physical barrier, altering sediment flow at the soil surface. The way the vegetation is spatially distributed along the slopes is an important factor for decreasing the sediment runoff. This barrier effect can lead to the formation of structures called phytogenic mounds. Such structures are found on the upslope side of large strips of grass disposed perpendicular to the slope. It reduces the sediment slip in channels.

The soil surface without vegetation causes more loss of upper crust of soil, it causes the silting problem in the channel beds ultimately reduced carrying capacity of the river and inundation like situation develops.

Learning Unit 2.3: Flood Damage Aggravation Factors

Flood is known for its damage, the causes mentioned in LU 2.2 are the static in nature which defines only the situation that governs the circumstances of flood-like situation. In this unit, we will discuss the factors that largely determine the quantum of damage though these factors are interlinked and depend on various associated circumstances in conglomeration, it causes impact in the form of flood damage.

Flood Damage Aggravation Factors:

- **Depth of water:** It indicates the level of inundation at a particular point and at a particular time. It is most important in crop damage estimation as it causes beneficial and detrimental effects on crops.
- **Duration:** If any place is inundated at a particular time, duration counts as up to what time the water was stagnant. The higher the duration, the higher is the risk in general, except in specific cases.
- **Velocity:** It is "the rate at which an object changes its position." It indicates the rate of movement of water per unit of time. It has a water head thrust force, which may be a causal factor of risk.
- **Rate of rise:** It indicates the rate of water level rise. Greater the speed, the more risk it will exert.
- **Frequency of occurrence:** It speaks about how often flood occurs. The higher the frequency, the higher is the risk.
- **Seasonality:** Seasonality speaks about regular and predictable changes that recur in every calendar year. It specifically speaks about the monsoon season for floods.
- **Siltation** is the natural aging process of the river channel. Due course of time, all channels silt it up causing the spread of water. Rivers arising in the mountains flow very fast in upper reaches and carry enormous sediment, that gets deposited in their beds. It reduces the carrying capacity of the river which results in the spread of water.

- **Capacity of River Basin** – The capacity of the river basin denotes the amount of water that can be transported by the basin. Due course of time, silting fills the basin that reduces carrying capacity.
- **Water Velocity** – Water flow rate depends on the water head potential. Water head is the product of the gradient. Sometimes high velocity of water with pebbles and stones may cause serious damages. In the case of floods, flow disrupt the process of rescue and relief.

Learning Unit 2.4: Anthropogenic Interventions and Losses

In earlier learning units we have studied the factors and situations that are associated with flood as the flood is the overflow of water from their normal confinements. The flood confinements may be a flood plain and any old channels.

The new land use pattern (Urban floors) refrains the natural percolations, and promotes speedy and excess flow of rainwater that causes river bank & soil erosion in urban skirts results extra sediments load in channels results causes flooding.

In this learning unit, we will discuss the human interventions that cause flood and loss made by flood.

Anthropogenic Interventions & Losses:

Floods are a natural hazard but it becomes a disaster when it causes loss of life and property. The magnitude of flood damage depends on the following anthropogenic activities.

Uses of floodplains: Flood plains are the alluvial plain of the river. When water gets receded, the flood plains undergo various uses by the public. The use of flood plain is high in the city which is facing high urbanization pressure. Flood plain contributes to disaster by endangering humans and their assets. However, the economic benefits of living on the floodplain outweigh the dangers for some societies. Pressures from population growth and shortages of land also promote settlement on floodplains. Floodplain development can also alter water channels which if not well planned can contribute to turning from hazard to disastrous flood.

Urbanization: The urbanization rate is much higher than our planned structures that contribute to urban flooding in the following ways:

- Roads and buildings cover the land preventing infiltration that turns runoff forms in artificial streams.
- The network of drains in urban areas may deliver water and fill natural channels more rapidly than naturally occurring drainage, or maybe insufficient and overflow.
- The natural or artificial channels become constricted due to debris, or obstructed by river facilities, impeding drainage and overflowing the catchment areas.

Deforestation: Exceptional chopping and removing trees freed up soil in major bulks. When soil becomes free, it exhibits in the form of major silting and debris in river channels.

Failure to maintain or manage drainage systems, dam, levee, and bank protection failure in vulnerable areas also contributes to flooding.

Losses due to Floods:

Flood damage occurs suddenly and quickly causing **direct** and **indirect losses**.

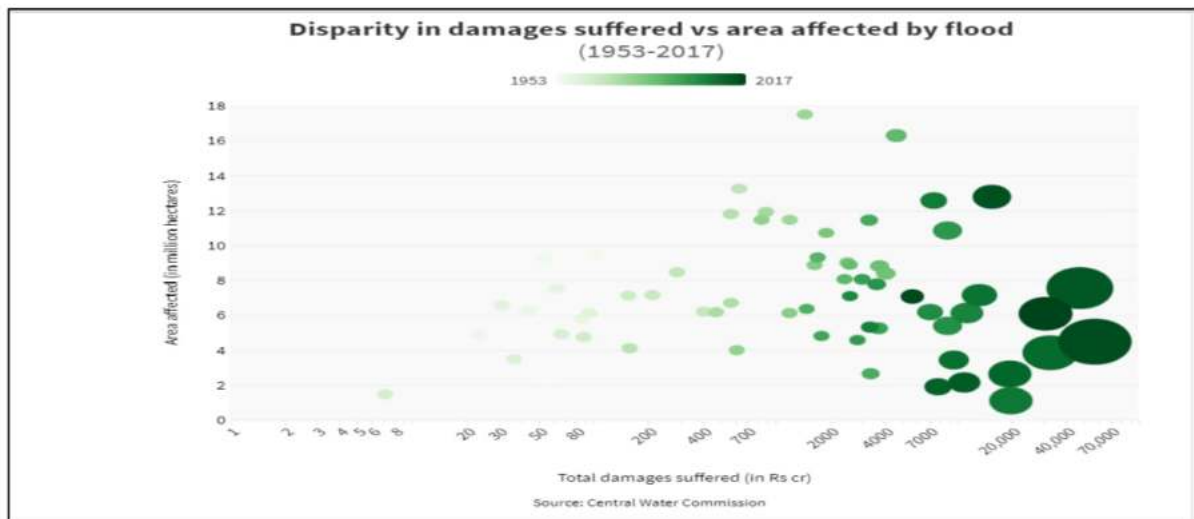
Direct losses relate to:

- Lives
- Crops
- Residential property
- Livestock
- Public utilities like highways, communication and business

Indirect losses arise from:

- Dislocation of agricultural operations
- Loss of interest on investments
- Loss due to business gaps
- Disruption of rail/road transport and Communications.

India is the second most flood-affected country in the world. Floods are more or less an annual phenomenon. The intensity is growing alarmingly owing to the cumulative effect of activities by man. The problem of floods is compounded by siltation, drainage blockage, and funnel effects of creeks or some time due to storm surge in the coastal areas.



Source: www.cwc.gov.in

Figure 17: Disparity in damages are affected by flood

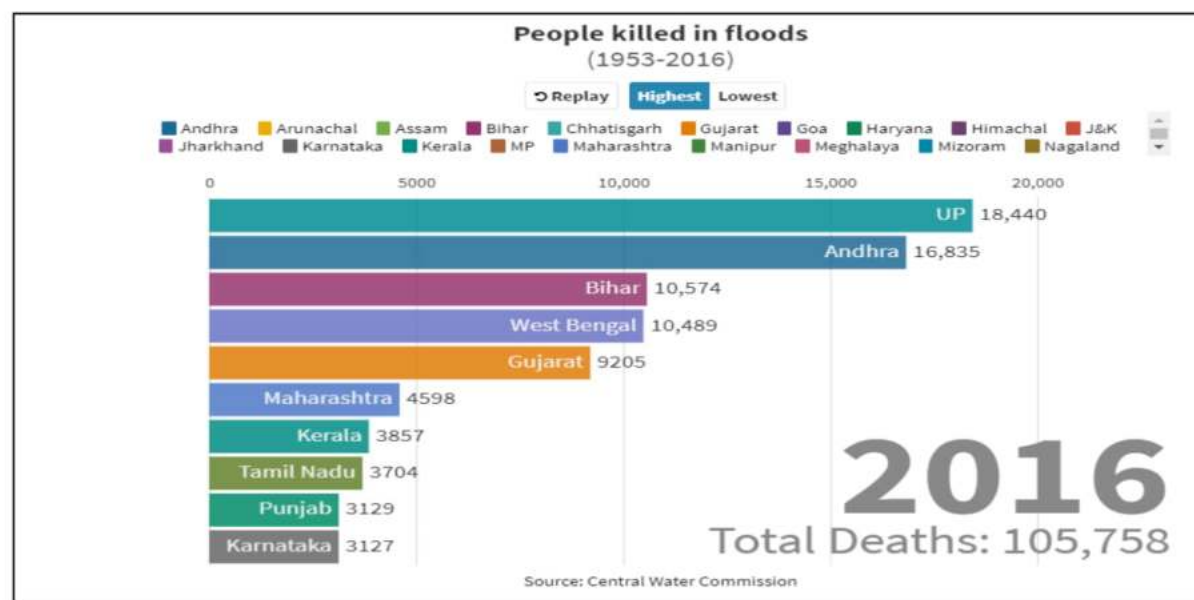
As per an estimate of the NDMA report, around 12% (40 million hectares) of land in the country is subject to flood.

India accounts for one-fifth of the global death count due to floods and over 3.6 million people being displaced annually due to disasters. The annual flood damage is estimated to have shot up nearly 40 times from an average figure of Rs. 60 crores per annum during the 1950s to an incredible figure of more than Rs 2550 crores per annum at current prices in the year 2018.

The flood-affected area shot up from an average of 6.4 million hectares in 1950s to 9 million hectares in 1980s, 40 Million hectares in 2017 with major economic loss.

Based on data from 2001-12 the annual **average** flood damage is as follows:

- Number of lives lost = 2143
- Number of Cattle Lost = 89891
- Number of Houses Damaged = 1445294
- Cropped Area affected = 40.32 (Lakh hac.)⁹



Source: www.cwc.gov.in

Figure 18: State wise Casualty due to floods

Notwithstanding flood policy and flood control schemes, **flood damage is increasing, with larger populations subjected to distress in increasing/populating flood-prone areas.** The focus has shifted away from the Gangetic belt. The distribution of damage is widespread, with the worst-hit being Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu in the south; Maharashtra, Gujarat and Rajasthan in the west; Uttar Pradesh in the north; Bihar and West Bengal in the east.

Flood Events in Gujarat:

The floods are reported once almost every two years in some districts of Gujarat located in Saurashtra, Kutch, and Northern Gujarat. Ahmedabad, Surat, Vadodara, and Bharuch cities are being affected as they are located on the flat alluvial plains of major rivers.

In 1997, flooding affected Mehsana, Gandhinagar, Ahmedabad, Kheda, Sabarkantha, Vadodara, Banaskantha and Surendranagar.

The 1998 flood had caused medium to heavy damage across the State. Heavy rains and consequent flooding in 2004 also caused widespread damage, particularly in Surat, Navsari, and Bharuch districts.

Flood 2006 affected 20 districts, 132 talukas, and more than 8,000 villages while the 2013 flood-affected 14 districts and around 1568 villages.

In 2015, heavy rain and flood caused widespread damage, particularly in Amreli and Banaskantha districts.

In 2017, the monsoon commenced early with heavy rainfall. By July 21st, 2017, the State had received almost half (45.90%) of the entire season's average rainfall. In the next seven days, it received a quarter of the season's rainfall (26.57%) Surendranagar was first hit by heavy downpour that started from July 14. The district received over 110 mm of rainfall – nearly 20% of its annual average in nearly 24 hours on July 21-22, 2017. Banaskantha too recorded a whopping 257 mm of rainfall, nearly 40% of the annual monsoon rainfall in nearly 24 hours on July 24-25, 2017. The flood situation compounded further with a major breach in the Narmada canal near Khariya village, Kankrej taluka, Banaskantha. State reservoirs, both natural and man-made, were already full. Unprecedented rainfall during July 2017 resulted in very heavy inflow into the dams such as Sipu, Dantiwada, Machhu, Dharoi.

In 2019, Vadodara city received 424 mm rainfall pouring within a very short span of six hours from 2 pm to 8 pm on 31st July 2019. The floodwaters inundated city Vadodara and washed away villages, damaged/destroyed houses caused loss of life and extensive damage to property. The heavy rains have left many of the major dams full while the medium and small dams are overflowing, the worst being the case Vishwamitri river, which flows through Vadodara, was reported 23 feet against its danger levels of 26 feet. The nearby Ajwa dam's water level also increased to 209.45 feet against its warning level of 215 feet. Much of the overflowing water was been drained into the Vishwamitri river flowing through the Baroda city.¹⁰ The Flood risks in Saurashtra are lower than the flood risks in the plains of Southern Gujarat. The relatively flat plains in lower basin areas with hilly catchments in the upper parts of South Gujarat accentuate flood risks¹¹.

Learning Unit 2.5: Flood Hazard Assessment

Flood Hazard Assessment:

Flood hazard assessment is the estimation of the probability of a flood occurrence with a particular intensity over an extended period. Flood hazard assessment is to estimate flood probability over periods of years to decades to support risk management activities.

Flood Intensity usually refers to the combination of flood depth and horizontal flood extent.

Return Period is an average time or an estimated average time between flood events.

1. **Discharge Frequency Analysis:** It is to estimate peak discharge, or the maximum flow rate of water that passes at a particular location in flood.

This approach relies on the existence of long records of accurate river discharge measurements. Usually, the highest recorded discharge in each year is used in the analysis.

Important Point that must be considered are:

1. The discharge records must be of good quality
2. The discharge records must be sufficiently long to estimate the return periods
3. The temporal resolution of the discharge record must be fine

2. **Rainfall-Runoff Modeling:** It represents the movement of water across the landscape. It is about the estimation of peak discharge or an estimate of the flow rate in the past at a certain location over a period of time.

The two most popular models are the Lumped Model and Distributed Model

Lumped Model:

Lumped models treat the watershed as a single unit. Calculations are performed using simplified, spatially averaged processes. The resulting discharge estimate only applies to the watershed outlet (the most downstream modeled point of the river network). Well-known lumped models include TR-55 and other unit hydrograph-based methods.

Distributed Model:

Distributed models use spatially varying input data for processes such as precipitation, infiltration, interception, interflow, infiltration, and base flow estimating discharge or other variables. This kind of model demands more data than lumped models but are more flexible and can be more accurate. Distributed models are often intended for use at a particular scale range, such as small urban watersheds (SWMM, GSSHA, Vflo, OpenLISEM) or large river basins (VIC). Most distributed models, if properly used, can provide discharge estimates at various locations along the river networks.!

! https://www.preventionweb.net/files/51114_capramethodsinfloodhazardandriskass.pdf

3. Hydraulic Modeling:

The two most common classes of hydraulic models are:

1-Dimensional (1D):

1D models are simplified models that characterize the terrain using a series of cross-sections. At each cross-section, the flow depth and velocity perpendicular to the cross-section is computed. These models are well suited for areas where the flow direction is well defined. The best known 1D model is **HEC-RAS**.

HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. HAC-RAS model the water flowing through systems of open channels and computing water surface profiles. HEC-RAS finds particular commercial application in floodplain management. It is also used in bridge and culvert design and analysis, levee studies, and channel modification studies.

Basic computation in the HAC-RAS program is based on the solution of the one-dimensional energy equation.

2-Dimensional (2D):

2D models calculate the flow both parallel and non-parallel to the main flow. They are useful for modeling areas of complex topography such as wider floodplains or broad estuaries but require high-quality data and can require long computation times. Examples of 2D models include **TELEMAC 2D, SOBEK 1D2D, and Flo2D**. Because of their greater sophistication, most 2D models are not freely available.

TELEMAC is short for the open TELEMAC-MASCARET system. Its 2D hydrodynamics module, TELEMAC-2D, solves the so-called shallow water equations. TELEMAC-2D solves the Saint-Venant equations using the finite-element or finite-volume method and a computation mesh of triangular elements.

TELEMAC may be used in assessment of:

1. Propagation of long waves, taking into account non-linear effects
2. Bed friction
3. Influence of Coriolis force
4. Influence of meteorological factors: atmospheric pressure and wind
5. Turbulence
6. Torrent and river flows
7. Influence of horizontal temperature or salinity gradients on density
8. Cartesian or spherical coordinates for large domains
9. Dry areas in the computational domain: intertidal flats and flood plains
10. Current entrainment and diffusion of a tracer, with source and sink terms
11. Monitoring of floats and Lagrangian drifts
12. Treatment of singular points: sills, dikes, pipes

SOBEK 1D2D a unique, fully integrated modelling framework for a multi-disciplinary approach and 1D-2D computations for river systems and estuaries, irrigation and drainage systems and wastewater and storm water systems. It can carry out simulations of flows, rainfall-runoff, sediment transports, water quality, morphological developments and ecology. It has been designed for experts and non-experts alike. SOBEK 1D2D is license version but it is also available in trial copy mode with some functional limitations.

Flo2D: FLO-2D has become the most widely used commercially available flood model. Flo2D is commercially available flood model. It has capability to simulate urban flooding in high resolution and unlimited detail including the **storm drain system**. Using elements as small as 10 ft (3 m), FLO-2D is a superior model in terms of volume conservation, speed, numerical stability and detail.

Most comprehensive and affordable 2-D flood routing tool with the following features:

1. Full storm drain/surface water interface
2. Channel-storm drain exchange
3. Manhole popping
4. Rainfall/infiltration with spatially varied NEXRAD data
5. Wall and building flow obstruction
6. Building roof runoff, downspout control, parapet walls
7. Wall and levee breach and collapse
8. Building collapse

MIKE 11: It is a computer program developed by Danish Hydraulic Institute (DHI), an international water software development and engineering consultancy firm. MIKE 11 is a 1-dimensional river model. It simulates flow and water level, water quality and sediment transport in rivers, flood plains, irrigation canals, reservoirs and other inland water bodies. Its computational core is a hydrodynamic simulation engine, and it has a wide range of additional modules and extensions covering almost all conceivable aspects of river modeling.

Its main application areas are flood analysis and alleviation design, real-time flood forecasting, dam break analysis, optimization of reservoir and canal gate/structure operations, ecological and water quality assessments in rivers and wetlands, sediment transport and river morphology studies, salinity intrusion in rivers and estuaries.

Learning Unit 2.6: Flood Vulnerability and affected areas in India & Gujarat

Flood Vulnerability and Flood Affected areas:

Vulnerability is the degree to which a system is susceptible and unable to cope with adverse effects. Flood vulnerability is firmly rooted in how people or societies are likely to be affected by flood phenomena – that is, the sensitivity of the community or people to flooding considering the socio-economic, environmental, and physical components.

Vulnerability Dimensions:

Vulnerability assessment is an essential part of disaster risk reduction. Vulnerability has emerged as a widely used concept in global environmental change, disaster risk management, and climate change adaptation. Vulnerability assessment entails both the identification and the reduction of the susceptibilities of the exposed elements. It is deemed a crucial step towards reducing the consequences of natural hazards and disaster risks.

Vulnerability is often exacerbated by socioeconomic inequalities, poverty, high population density, lack of awareness, weak institutions, and poor infrastructure.

To minimize the potential harm associated with disasters, communities' vulnerabilities and factors need to be measured. Recently, interest has been focused on working out vulnerability assessment methodologies, but these methodologies still require proper refining before they can be included in policies.

Vulnerability is multifaceted and includes diverse components using social, economic, physical/infrastructural, institutional, and attitudinal dimensions. This multidimensional vulnerability assessment would greatly help in identifying a relevant course of action for disaster risk reduction in exposed communities.

Vulnerability has been viewed through the lens of multiple contexts, dimensions, and spatio-temporal scales, and there is no universal theory or model. biophysical and social dimensions (Cutter et al. 2000),¹² Pressure and release model explains the progression of vulnerability (Wisner et al. 2004, Schroter et al. 2005¹³, proposed eight-step approach of vulnerability, Birkmann (2006)¹⁴ broadened the theory of vulnerability by suggesting five spheres, including multidimensional features such as physical, social, economic, institutional, and environmental features.

Birkmann, 2013 recently proposed “Methods for the Improvement of Vulnerability Assessment in Europe” (MOVE)¹⁵.

It provides that vulnerability assessment has multidimensional characteristics but there has been no clear-cut and standardized methodology available for measuring the multidimensional aspects of vulnerability (Mazumdar and Paul 2016).¹⁶

Flood Vulnerability is the sensitivity of the community or people to flooding considering the socio-economic, environmental, and physical components.

These components can be understood through an assessment of flood vulnerability components and factors. Individuals and communities are differently exposed and are vulnerable to floods because of the socio-economic factors, such as wealth, education, race, ethnicity, religion, gender, age, class, disability and health status.

This is because flood vulnerability and adaptations are firmly related to the context of the natural environment and socio-economic factors of a specific area.

There are four major components of flood vulnerability, namely, social, economic, environmental and physical components.

Floods Trait in India:

i) Meteorological

The **main season for floods** in India is the southwest monsoon period (**June to September**), though floods occur in some parts of the country in the pre-monsoon season (March-May) and post-monsoon season (October-December).

During the pre-monsoon season, the Assam region experiences severe thunderstorms. The Brahmaputra River gets flooded during May partly due to thunderstorm rainfall and partly due to the melting of snow due to abnormal temperature conditions in its upper catchments. In the monsoon season, southwest monsoon sets in over Kerala towards the end of May or the beginning of June, which advances northwards and covers almost the entire country by the end of June.

Monsoon depressions and low-pressure areas form in the North Bay of Bengal (occasionally in the central Bay), and move in a north-westerly direction across central parts of the country giving rise to heavy and very heavy rainfall in the catchment areas of central India. Some of these depressions move in a northerly direction and affect catchments of north Indian rivers. Often

during the late monsoon in September middle latitude westerly waves move across north India resulting in heavy rainfall in the catchment areas of rivers originating from the Himalayas. By the middle of September, monsoon starts withdrawing from the northern parts of the country and more rainfall occurs over the northern peninsula.

South-eastern coastal areas get the bulk of rainfall and consequent local flooding during the northeast monsoon season (October-December). In pre and post-monsoon seasons, cyclones affect the east and west coasts, and the combined effects of torrential rains and storm surges occasionally lead to floods particularly in the coastal areas.

ii) Hydrological

Apart from the rainfall, some hydrological aspects that aggravate the flood situation are:

1. The inadequacy of the carrying capacity of the river channels
2. Erosion and silting of the riverbeds
3. Temporary blockage of water resulting in an artificial lake and when the blocking gives way, the downward rushing water causes a flood situation in lower reaches.

Flood Affected Areas in India

River floods are most frequent and most devastating in terms of annual loss of life and property. Nearly 75 percent of the total rainfall is concentrated over a short monsoon season in four months (June-September).

As a result, the rivers witness a heavy discharge during these months, leading to widespread floods. The country is divided into four flood-prone regions according to the river systems.

They are:

- i) The Brahmaputra region,
- ii) The Ganga region,
- iii) The Indus or northwest region, and
- iv) The Central India and Deccan region.

Attach Flood Vulnerability Map of India

The most flood-prone areas are the Brahmaputra, Ganga, and Meghna basins* 1 in the Indo-Gangetic-Brahmaputra plains in north and northeast India, which carry 60 percent of the nation's total river flow. The other flood-prone areas are the northwest region of the west-flowing rivers

*1The Ganga-Brahmaputra-Meghna basin is one of the largest in the world. In India it is spread over 15 states and covers a geographical area of 1.75 million square kms of which 75.8 per cent lies in India. About 47 per cent of India's population resides in the basin. The basin can be broadly divided into **four regions**: the Himalayan zone, the plains, the hilly tracts of the northeast, and the southwest hilly tracts along the fringe states in India.

like the Narmada and Tapi, central India and the Deccan plateau with major east-flowing rivers like the Mahanadi, Krishna, and Cauvery.

The Brahmaputra region:

This region covers Assam, northern parts of West Bengal, Manipur, Tripura, Nagaland, Arunachal Pradesh and Mizoram. The floods in this region are frequent and severe. The rivers like the Brahmaputra, the Barak, and their tributaries are flowing in this region. The catchments of these rivers get annual rainfall ranging from 110 cm to 635 cm. The rivers in this region carry considerable amounts of silt and tend to change their course. This region is also cursed by seismicity, landslides, high population density, heavy rainfall. It causes massive damage to property and lives.

The Ganga region:

The river Ganga and its numerous tributaries cover the Uttar Pradesh, Bihar, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, and south and central portion of West Bengal. The normal annual rainfall in this region is ranging from 60 cm to 190 cm. The flood problem is mostly confined to the northern tributaries of the Ganga, which overflow their banks. It tends to change their courses. The region suffers from drainage congestion. The flood & erosion problem is serious in the states of U.P., Bihar, and West Bengal.

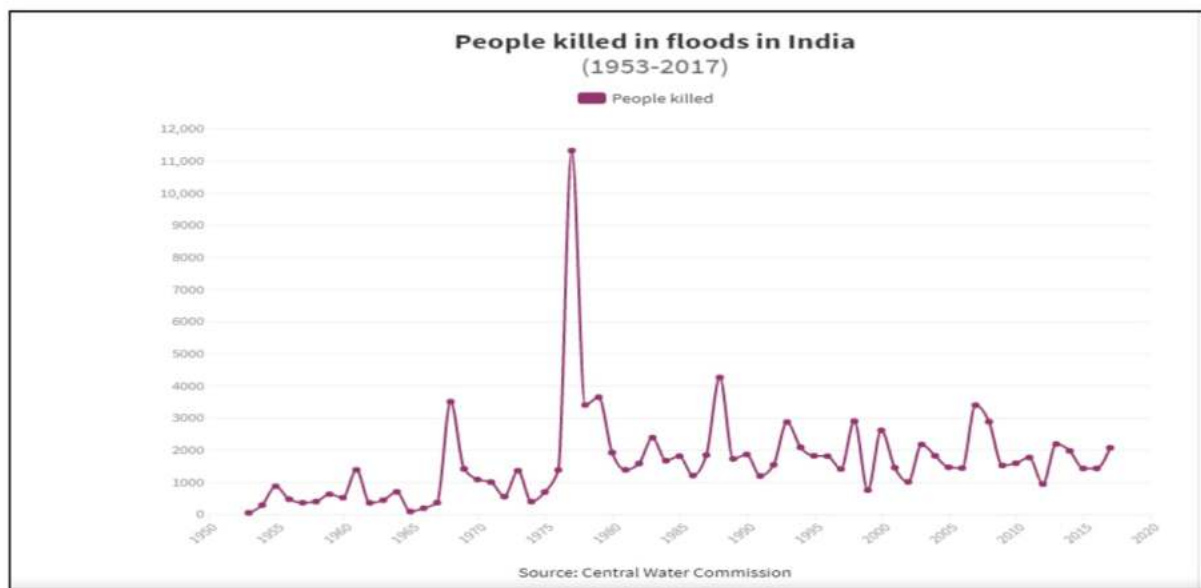
The Northwest Region:

The region covers the states of J&K, Punjab, parts of Himachal Pradesh, Haryana and Rajasthan. The main rivers in this region are the Sutlej, Beas, Ravi, Chenab, and Jhelum, all originating from the western Himalayas. These rivers carry substantial discharges in the monsoon, which contain heavy sediments. Compared to the Ganga and Brahmaputra rivers, the flood problem is less severe in this region. The flattened slope and inadequate drainage causes flood problem.

Central India & Deccan Region:

This region covers all the southern states (Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala) and the states of Orissa, Maharashtra, Gujarat, and parts of Madhya Pradesh. Important rivers in this region are Narmada, Tapi, Mahanadi, Godavari, Krishna, and Cauvery. These rivers have

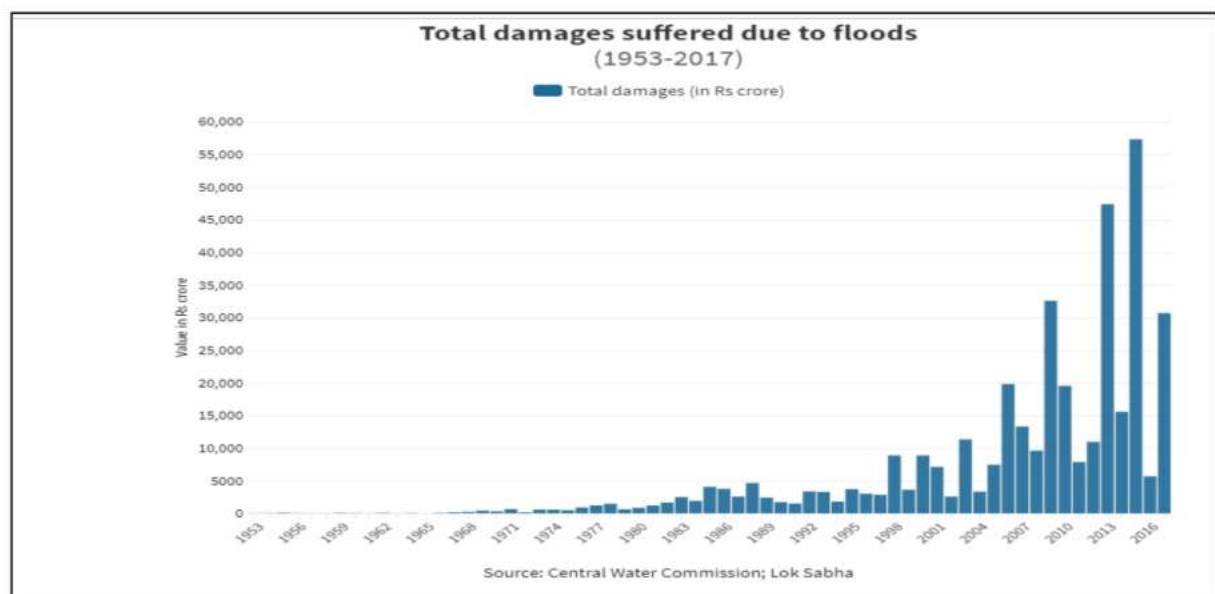
well-defined stable courses. They have adequate capacity within their natural area in the lower reaches of the basin in Gujarat.



Source: www.cwc.gov.in

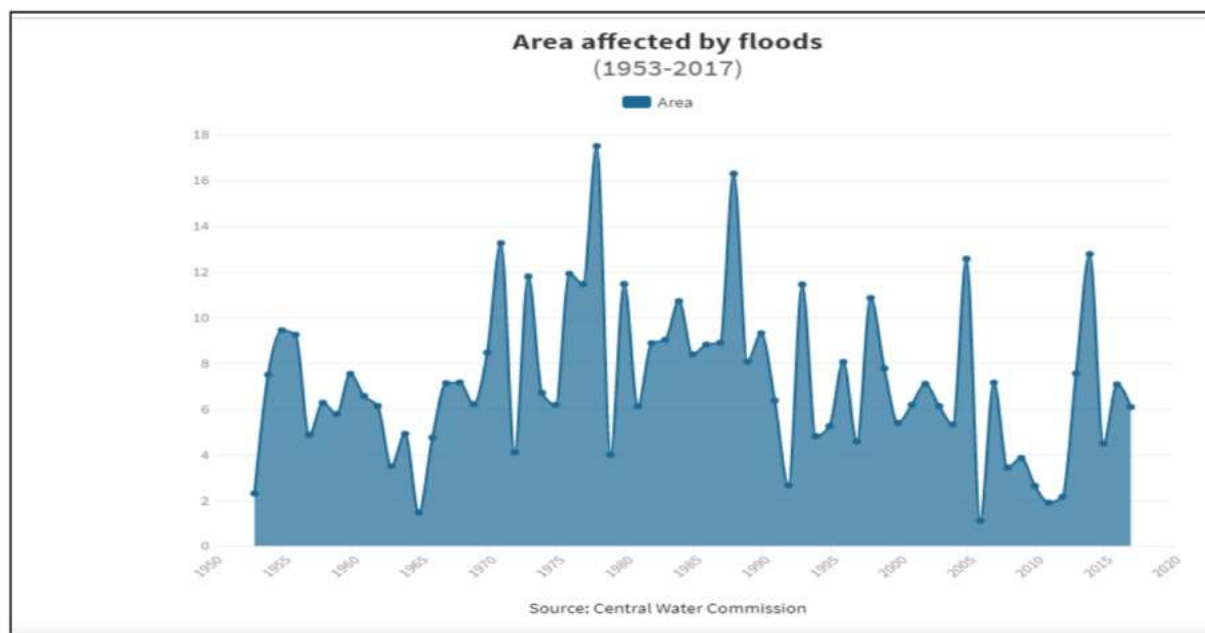
Figure 19: Total Casualty due to floods in India

In India flood-prone area has increased from 7.95 MHA in the 1950s to > 40 MHA in 2016's. Twenty-two states and one Union territory (Andaman & Nicobar) are vulnerable to floods. The states, which are most vulnerable to floods, are Uttar Pradesh, Bihar, Assam, West Bengal, Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat, Punjab and Jammu & Kashmir. The States with regular floods are Assam, North Bihar and Eastern parts of Uttar Pradesh. There are >137 districts in the country that are vulnerable to floods.



Source: www.cwc.gov.in

Figure 20: Total damages due to floods in India



Source: www.cwc.gov.in

Figure 21: Year wise Area affected due to floods in India

Flood Vulnerability in Gujarat:

“Flood Vulnerability” is vulnerability refers to the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazard. It is the degree to which a system, or part of a system, may react adversely to the occurrence of a Flood event.

Physical vulnerability is related to the physical location of the people and elements at risk, and their physical proximity to the flood hazard.

Socio-economic vulnerability indicates the degree to which a population is affected by a flood such as disruption in services like schools, hospitals, etc. It will not be strictly confined to the physical components but also depends on the prevailing social and economic conditions settlements or buildings that are near the river.

Gujarat state has seventeen rivers majority are on the flatbed. The longest coastline and wide variation in rainfall pattern making the Gujarat a vulnerable state for Flood.

All major rivers in the State pass through a wide stretch of the very flat terrain before reaching the sea. Cities like Ahmedabad, Surat, and Bharuch are located on the flat alluvial plains of large rivers; these flat lowlands are prone to flood.

A long coastline of Saurashtra and Kutch have fairly impervious (rocky or black cotton soils) surface. The upper catchments of these areas have a sharp slope, that possess high runoff potential. The occasional heavy rainfall causes most of the floods.

The southern part of the state is humid to sub-humid (Dang, Valsad, Tapi, Narmada, etc.) shows high rainfall. The relatively flat plains in the lower basin areas with hilly catchments in upper parts of South Gujarat accentuate flood risks.

Learning Unit 2.7: Flood Vulnerability Assessment

Flood Vulnerability Assessment:

Flood vulnerability assessment is an essential part of flood management. The goal of vulnerability assessment is to understand how a system will be affected by floods. Flood Vulnerability assessment is done by various methods like:

1. Indicator-Based Method
2. Index-Based Method
3. Modelling Method

Indicator-Based Flood Vulnerability Assessment:

Vulnerability indicators provide a logical Image of the vulnerable place. This method is widely used in flood vulnerability studies by policymakers to clarify vulnerability images over space. It is to depict the priority measures and plan for the risk response in a specified region.

Vulnerability Indicators are a variable that is an operational representation of a characteristic or quality of an object or subject able to provide information regarding the susceptibility, coping & adaptive capacity, and resilience of a system.

Three major factors (Exposure, Susceptibility, and Resilience) based indicators and their functional relationship with vulnerability are shown in the table:

Table 2: Indicator base flood vulnerability assessment

Defined indicator	Factors	Unit	Functional relationship with vulnerability (+ or -)
Flood frequency	Exposure	year	Higher is the number of flood events, higher is the vulnerability (+)
Flood duration	Exposure	days	The higher the flood duration, the higher the vulnerability (+)
Flood water depth	Exposure	m	The higher the flood water level, the higher the vulnerability (+)
The proximity of the village to the water body	Exposure	m	The Closer is the place to the river, the higher is the vulnerability (+)
Population in the flood area	Exposure	#	The higher the number of population, the higher the vulnerability (+)
Gender	Susceptibility	%	The higher the % of women, the higher the vulnerability (+)
Elderly	Susceptibility	%	The higher the % of elderly, the higher the vulnerability (+)

Children under 15	Susceptibility	%	The higher the % of children, the higher the vulnerability (+)
Agriculture workers	Susceptibility	%	The higher the % of household having agriculture activity the higher the vulnerability (+)
Female-headed household	Susceptibility	%	The higher the %, the higher the vulnerability (+)
Knowledge about flood hazard	Resilience	%	The higher the percentage, the lower the vulnerability (-)
Warning system	Resilience	%	The existence of warning system lowers the vulnerability (-)

Vulnerability indicators are widely used in vulnerability assessment. The first step in indicator-based vulnerability assessment is the *selection of the study area*; Secondly, *indicators based criteria*, such as the availability of data, personal judgment, or previous research¹⁷.

Index-Based Flood Vulnerability Assessment:

It is a quantitative assessment of vulnerability usually done by constructing a vulnerability index. The index is based on several sets of indicators that result in the vulnerability of a region. It produces a single number, which can be used to compare different regions in the area under observation.

The vulnerability may be assessed as the lack of institutional support and the right to participate in the decision-making process at any level i.e. local, regional, national, or international. Engineering vulnerability assesses how prone a system's ability to return to steady-state is; after disturbance events that affect e.g. infrastructure, land use, soil composition, and the agro-biodiversity in a community. It is possible to identify and develop indicators at specific localities to assess vulnerability based on the political, socio-economic, engineering, and ecological settings of localities.

The vulnerability index was developed to empirically assess relative levels of climate change-induced variations in water availability.

Table 3: Indicator base Flood Vulnerability assessment

S. No.	Vulnerability Category	Indicator	Indicator Description
1.	Engineering	Access to irrigation system	Access to irrigation mostly in the form of small dams including dug-outs allows a community to plant in the dry and wet seasons
		Access to Potable Drinking Water	Potable drinking water means access to protected dug well, borehole, protected spring, and rainwater collection.
		Involvement in Dry	

		season Farming	Involvement in dry season farming by a community either lying closer to a water body
2.	Ecological	<p>Landscape with high biodiversity</p> <p>Landscape with agro-forestry</p> <p>Crop diversification</p>	<p>General evidence of high floral and faunal diversity within a community either domesticated or naturally regenerating</p> <p>Presence of high density of domesticated or naturally regenerating tree species in farm lands.</p> <p>Availability of different crop types including cash crops and food crops that satisfy both household consumption and market</p>
3.	Socioeconomic	<p>Livelihood diversification (off-farm income source)</p> <p>Vulnerable groups (women, children, physically challenged)</p> <p>Migration rate/rural–urban migration</p>	<p>This involves availability of other income generating activities to supplement farming. It includes artisanal skills or trading, off-farm employment in local cottage industry etc</p> <p>Vulnerable groups who may need the assistance or depend on others in case of possible disaster risk</p> <p>Evidence of migration in the community, the sex of migrants, destination areas, engagement with household back home e.g. through remittance</p>
4.	Political	<p>Politically influential person.</p> <p>Community Stakeholder Organizations / CBOs.</p> <p>Assembly member.</p>	<p>Availability of a regional or national political figure or businessman hailing/residing in the community</p> <p>Existence of locally-based advocacy organization or presence of an external advocacy group working in the community</p> <p>Availability of an assemblyman residing in the community activities</p>

		Local participation in district activities	Level of household-level participation, advocacy, and interests in district level political activities.
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Table 4: Vulnerability Indicator Score

S.No.	Vulnerability Indicator Score	Value Assigned
1.	0–33.33%	3
2.	33.34–66.66%	2
3.	66.67–100%	1

Vulnerability Index (VI) =

As each indicator was seen as having either direct or indirect impact on community vulnerability, impact factors; direct or indirect, were assigned to each indicator as follows; The level of vulnerability for each category (i.e. ecological, socio-economic, engineering, and political) was calculated using the Eq. below:

$$\text{Vulnerability} = \sum_{k=0} ka^{n-k}$$

above equation represents the total vulnerability category to floods, (VI) represents the vulnerability indicator scores, n = sample size, a = impact factor. (direct impact = 1 and indirect impact = 0.5) and K = 2 (1+2+3/3). Total community vulnerability (TCV) was estimated from sum of ecological, social, engineering and economic vulnerability as shown in Eq. below:

$$\text{CTV} = \sum (\text{Ecological, Social and Economic Vulnerability})^{18}$$

Modeling Methods:

Computer models are the accurate method of flood prediction. It can evaluate the depth, elevation, and velocity of the flood by using frequency, magnitude, and shape of the hydrograph. This model may generate one-dimensional, two-dimensional flood simulations and delineation of flood zones. These methods depend on detailed data about topographic, hydrographic, and economic information. In lack of sufficient data, models suffer significant irregularities which can lead to assessment quality.¹⁹

Learning Unit 2.8: Flood Risk Assessment

Flood Risk:

Risk is exposure to an undesired event. It can be expressed in terms of the probability that the event will happen. "Flood Risk" is the likelihood of a flood event together with the actual damage to human health, lives, environment, and economic activities. The quantification of flood risk results either in monetary units or in loss of life units.

Flood risk is determined by the summed probability of flood hazard, as well as the assets at risk due to this. It can be expressed in terms of the probability that the event will happen. The large, catastrophic floods have a very low frequency or probability of occurrence, whereas smaller floods occur more often. The more the number of years in a recurrence, the smaller the chances of flood experience.

Flood Risk Assessment:

There is a wide range of flood risk assessment methods to assess flood risks. It requires the estimation of flood hazard and the harmful impacts that it can cause to lives, properties, and the environment.

Proper estimation of risk is challenging and it requires careful consideration of several factors, like hazard, vulnerability, exposure, and coping capacity. It certainly includes watershed properties such as size, topography, land use, types and characteristics of storms that produce rainfall and flooding in the region. Moreover, it also considers the number, location, types of buildings, and other assets that could be damaged.

Flood Risk Assessment can be made by four of the following steps:

1. Risk identification: refers to the identification of the hazard source, be it heavy rainfall, river overflow, dam burst possibilities and storm surge etc.

2. Risk analysis or risk estimation: refers mostly to the probabilistic quantification of the average annualized risk and it is measured in the same units as a hazard. It involves the estimation of the probability of occurrence of the hazardous phenomenon, the estimation of the actual consequences, and the vulnerability estimation of the affected system over the selected hazard scenarios.

3. Risk evaluation: refers to the identification of the local society's tolerable risk policies and criteria as well as to the comprehension of the local society's perception of the hazard impacts by the decision-makers. One's willingness to pay for risk reduction is controlled by the perceived and not the actual risk. Simultaneously the perceived risk reflects the human attitude towards various kinds of risks and it is therefore of high importance to assess it.

4. Risk Assessment: refers to the evaluation of the tolerability of the estimated risks based on the local society's acceptability criteria. The comparison of the estimated risks with acceptable ones results in the decision of what risk will be acceptable in the particular affected system and what risk reduction measures will be applied; if needed.

Flood risk assessment shows the potential risk to the population, economy, and environment due to flooding.

Generally, there are three methods of Flood Risk Assessment:

- (a) Hydrological models** such as SWAT, HEC-RAS, and FLORA-2D
- (b) Nonlinear machine learning algorithms** such as decision tree, artificial neural network, support vector machine, and random forest
- (c) Quantitative approaches** such as frequency ratio, logistic regression, weights-of-evidence, genetic algorithm, differential evolution, and analytic hierarchy process.

The abovementioned methods successfully provided a flood risk assessment, but every method faced some limitations. In hydrological modelling, the preparation and calibration of parameters are time-consuming and have high computer resource requirements.

Quantitative modelling, such as statistical and data-driven methods, increases the subjectivity and uncertainty because they require an expert to select the flood conditioning factors.

Nonlinear machine learning algorithms may lead to poor projections due to the large and inconsistent value ranges in the datasets in data-scarce areas

Data Required for Determining Flood Risk:

1. Site-specific data such as stream gaging records
2. Rainfall records
3. Historic information – flood marks on buildings and other structures, areas flooded (discuss with longtime residents)
4. Newspaper accounts, diaries

5. Marking of flood levels after an event
6. Botanical evidence such as scars on trees
7. Physical and geomorphic techniques, e.g., look at boulders along streams, water transported debris along walls of canyons
8. Regional information, i.e., look at flood occurrences along similar streams in the area

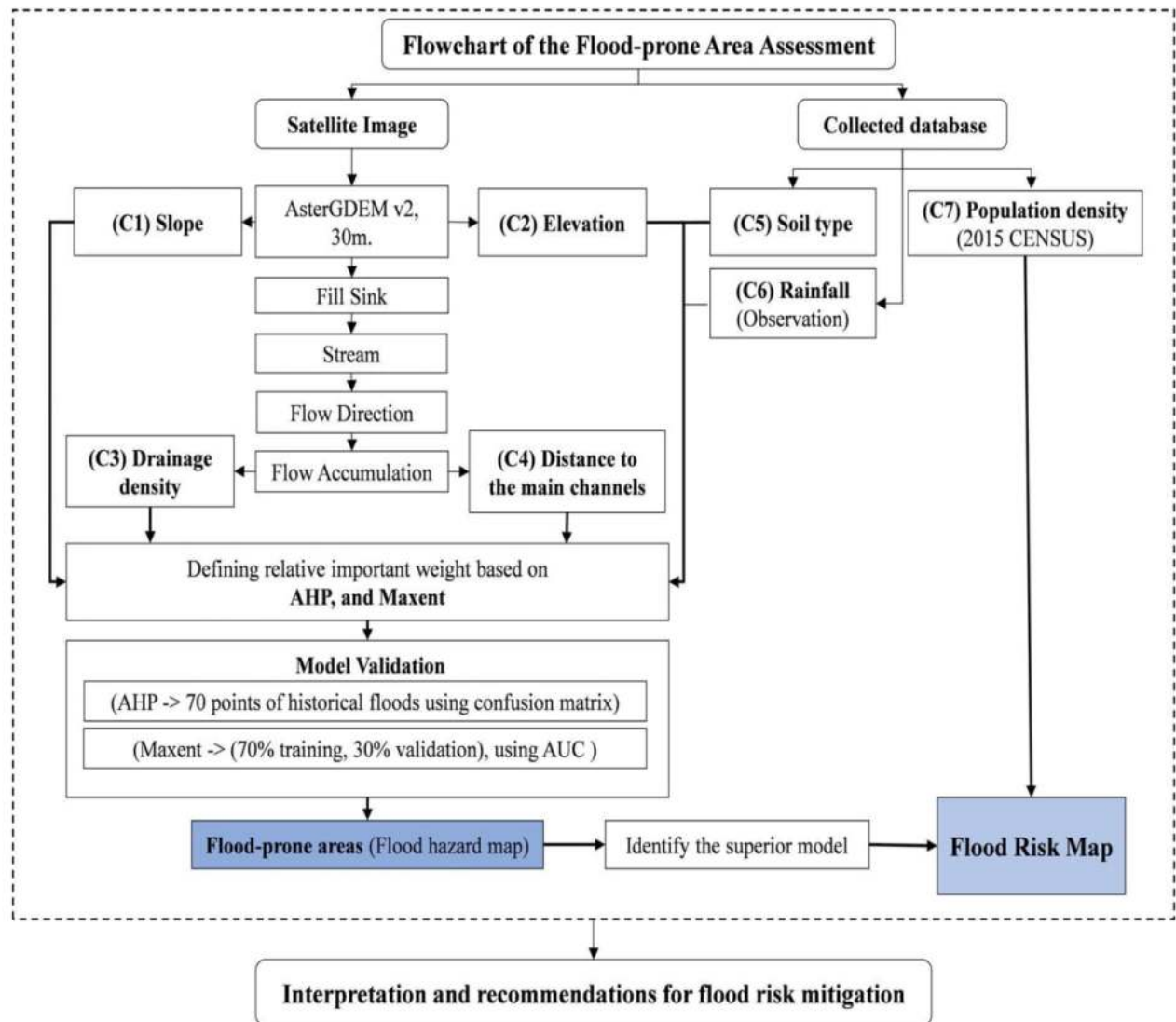


Figure 22: Flow Chart of Flood Prone Area Assessment

Technical Session 3:

Flood Risk Prevention, Mitigation & Preparedness

Introduction

Prevention, Mitigation & Preparedness of the flood hazard can play a very important role to save the lives of the people. The first step is to identify areas that are at risk and then the reasons responsible for the conditioning. This session will focus on various measures to reduce the flood risk situations.

Objectives

The objectives of the session are to introduce about:

- ❖ Flood Risk Reduction Measures
- ❖ Structural & Non-structural measures
- ❖ Various ways to combat possible flood risks.

Learning Units:

LU 3.1 Structural Measures of Flood Risk Management

LU 3.2 Non-structural Measures of Flood Risk Management

LU 3.3 Flood Preparedness Measures & Checklist

Duration: 75 minutes

Suggested Methods

Interaction, Presentation, and discussion.

How to Conduct

- ❖ Ask the participants as to what do they know about the structural & non-structural measures.
- ❖ Discuss the different Preparedness & Mitigation Measures.
- ❖ Make a brief presentation. Invite questions and clarify the points raised by the participants.

Learning Unit 3.1: Structural Measures of Flood Risk Management

Protection to all flood-prone areas for different probabilities of occurrence on all magnitude is neither practically possible nor economically viable. Hence, a practical approach in flood risk management is to provide a reasonable degree of protection, against flood damage at economic costs through a combination² of structural measures.

Structural Measures of Flood Risk Management:

Structural measure refers to those mitigation tools which have a physical entity such as embankment, dam, etc., it is a measure to control the physical process of flooding.

Structural measures with adequate appurtenant structures and proper water management practices create conditions for increasing productivity from land and other developmental activities.

Structural measures are physical, it aims to prevent floodwater from reaching potential damage centers and keep control over floods (reservoir operation, upstream catchments management, channel modifications, levees, operation of hydraulics works).

Structural measures aim at protecting an area up to a certain level of flooding:

It may be divided into five categories:

- (a) Storage reservoir or basins to restrict overflow
- (b) Retarding basins to lower the flow of flooding
- (c). Levees and floodwalls to confine floodwaters
- (d) Improvement of channel capacity
- (e) Some structural measures such as Flood Embankment, Channel Improvement, River training, Coastal Embankment etc.

Among these structural measures, the construction of embankment is the most popular practice.

There are some options for structural measures-

- ❖ Dams and Reservoirs for impounding excess runoff. Detention basin, Retention Pond, Embankment, Dyke, Polder, Levee, Bund, or Floodwall to block the movement of water from rivers to floodplain.
 - ❖ Flood bye pass, flood diversion
 - ❖ Watershed Management and afforestation
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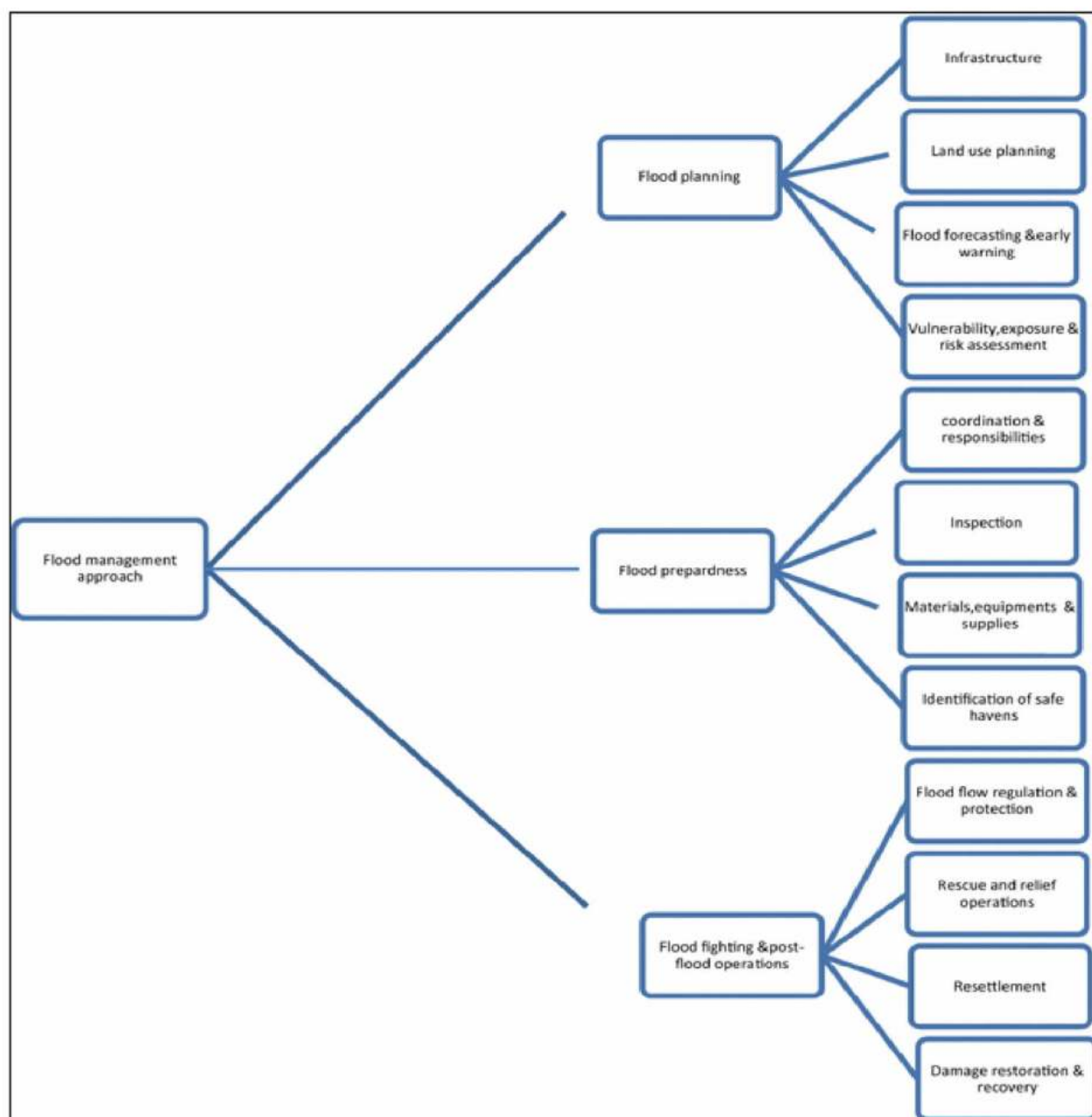


Figure 23: Flood Management Approach Sketch Diagram

Dams

Dams are barriers that impound hydrologic flows. Dams retain floodwater before they reach areas at risk. For example, during high-precipitation periods, dams hold up floodwaters that are released gradually to minimize the likelihood of damage to downstream areas. However, during exceptionally large events, the storage capacity of a dam can be exceeded and uncontrolled flood flows are passed downstream. Under these circumstances, downstream levees may not be able to contain floodwaters and causes flood.

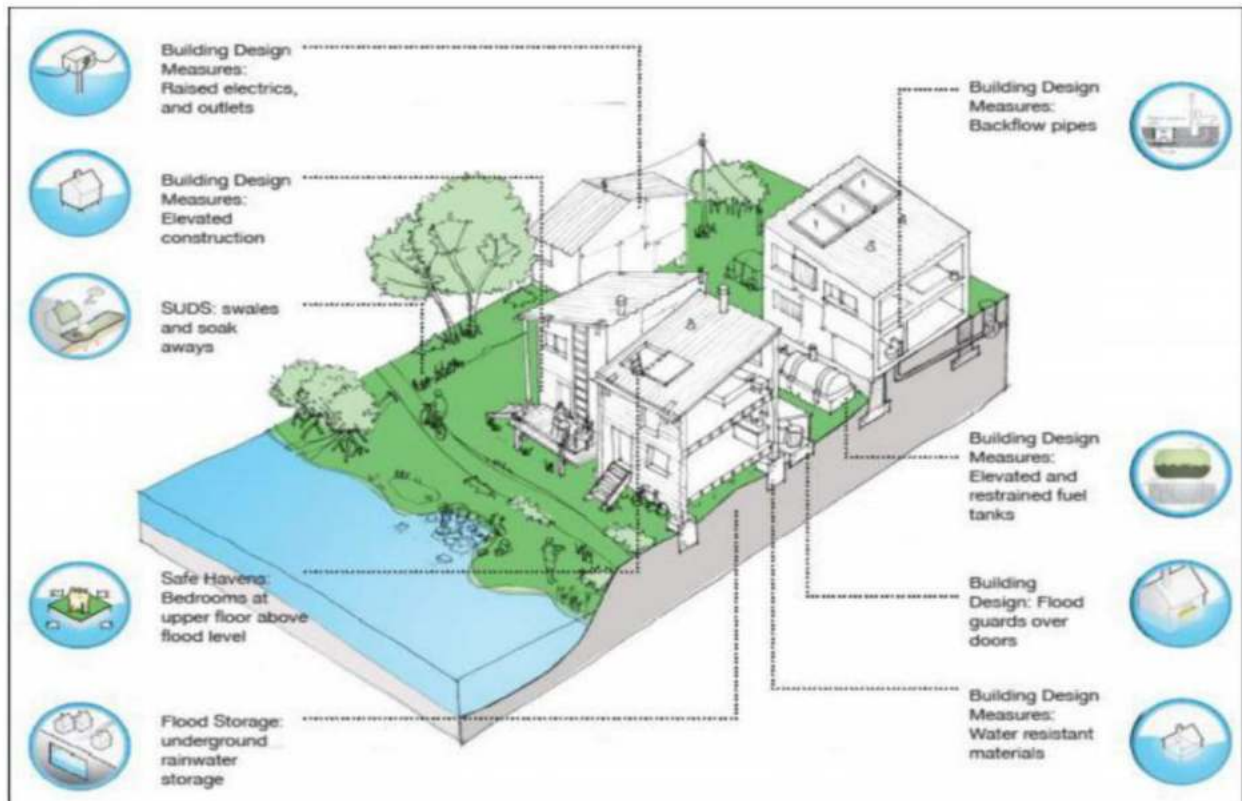


Figure 24: Sketch Diagram of Structural Measures for flood

Levee & levee overtopping:

A levee, flood bank or stop bank is a natural or artificial embankment. Levee is to prevent flooding of the adjoining areas; levee confine the flow of the river resulting in higher and faster water flow towards downstream. During a flood event, the risk of a levee overtopping may be significant and the consequences can be catastrophic.



Figure 25: snapshot of Levee

Controlled overtopping of levees or engineered overtopping involves designing a levee to stop overtopping in the least hazardous location. This can be done by using different levee heights, known as superiority, or notches or openings in a desired location.

The advantages of controlled overtopping in a designated area are:

- (1) Reducing the impact of overtopping in the selected area and other parts of the levee system,
- (2) Reducing the likelihood of overtopping in less desirable areas (i.e., areas with more development)
- (3) Reducing levee maintenance and repair costs after the flood event

Flood Diversion:

Diversion structures route runoff over base flow to storage facilities during wet periods, for later use in the dry period. Flood diversion structures, such as dikes, are also useful methods for mitigating the adverse effect of torrential rains and at the same time capturing the excess water for later use.

Transverse Dikes

Transverse dikes are built in sections along a river to store excessive runoff. These dikes can be built using material dredged from the river or transported from adjacent lands. The dike material, usually clay or silt, must be highly compacted and in many cases, it is advisable to place riprap on the dike to increase its strength and protect it from erosion.

Water Traps

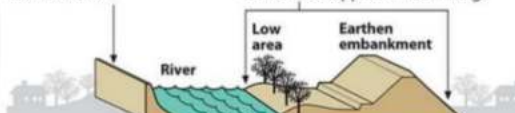
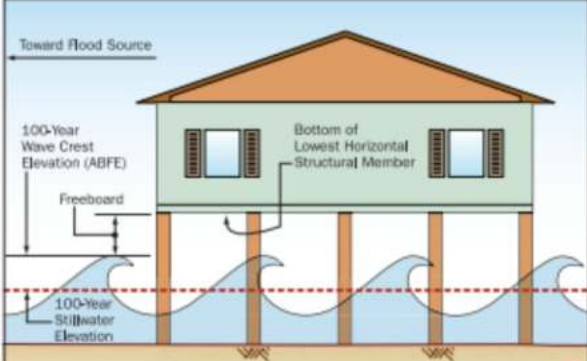
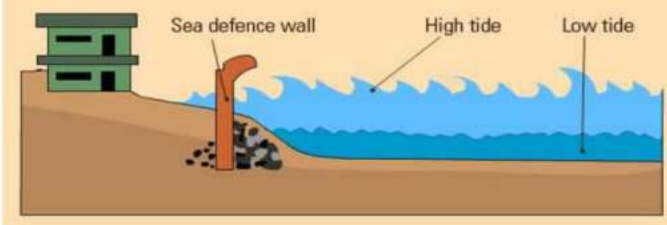
Water traps are used to control the deleterious effects of runoff in a river basin and to facilitate water storage and the recharge of aquifers. They are built like an earth dam, usually 1 m to 3 m high, using local materials. The walls are compacted in 20 cm layers using the same equipment as is used to build a dam.

Watershed & Afforestation:

Watershed management is the process of guiding and organizing the use of the land, water, and other resources on a watershed to provide desired goods and services without harming soil and water resources.

These are the practices of maintaining the inter-relationships among land use, soil and water, and the linkages between uplands and downstream areas. It practices the changes in land use, vegetative cover, and other structural actions that are taken to achieve specific watershed management objectives. Forests and Trees affect the hydrologic behavior of a watershed, including the quantity and quality of streamflow, erosion, and sedimentation. In general, natural

forests yield the highest quality of water in any ecosystem. The lowest erosion and sedimentation rates are usually associated with forested watersheds in natural conditions, streamflow from forested watersheds tends to be more uniform, with peak flows lower than those from watersheds with another vegetative cover. Given this background, the role of trees and forests can be viewed in terms of watershed Protection enhancement of water resources, and flood control activities. Such approaches and practices are useful in flood control and the integrated approach of resource management.¹⁵

Flood Risk Reduction through Flood Wall	Flood Risk Reduction through building Design				
<div><p>Methods of flood control</p><p>The two most common ways to try to contain flooding rivers:</p><div><div><p>FLOOD WALL</p><p>Barrier built along river-banks – made of concrete, stone or brick</p></div><div><p>LEVEE</p><p>Wide embankment built along river-banks – made from clay, sand, or soil; sometimes topped with sandbags</p></div></div><p>LEVEES ALONG THE MISSISSIPPI RIVER</p><table><tr><td>More than 2,000 miles of levees have been built</td><td>Height: 15 ft. to 30 ft.</td><td>Width: 8 ft. on top</td><td>More than 100 ft. at the base</td></tr></table></div>	More than 2,000 miles of levees have been built	Height: 15 ft. to 30 ft.	Width: 8 ft. on top	More than 100 ft. at the base	 <p>Exceeding NFIP Elevation Requirements in Coastal A Zones and V Zones</p>
More than 2,000 miles of levees have been built	Height: 15 ft. to 30 ft.	Width: 8 ft. on top	More than 100 ft. at the base		
Flood Risk Reduction through Defence Wall System					
					
Flood Risk Reduction through Land Use Planning					

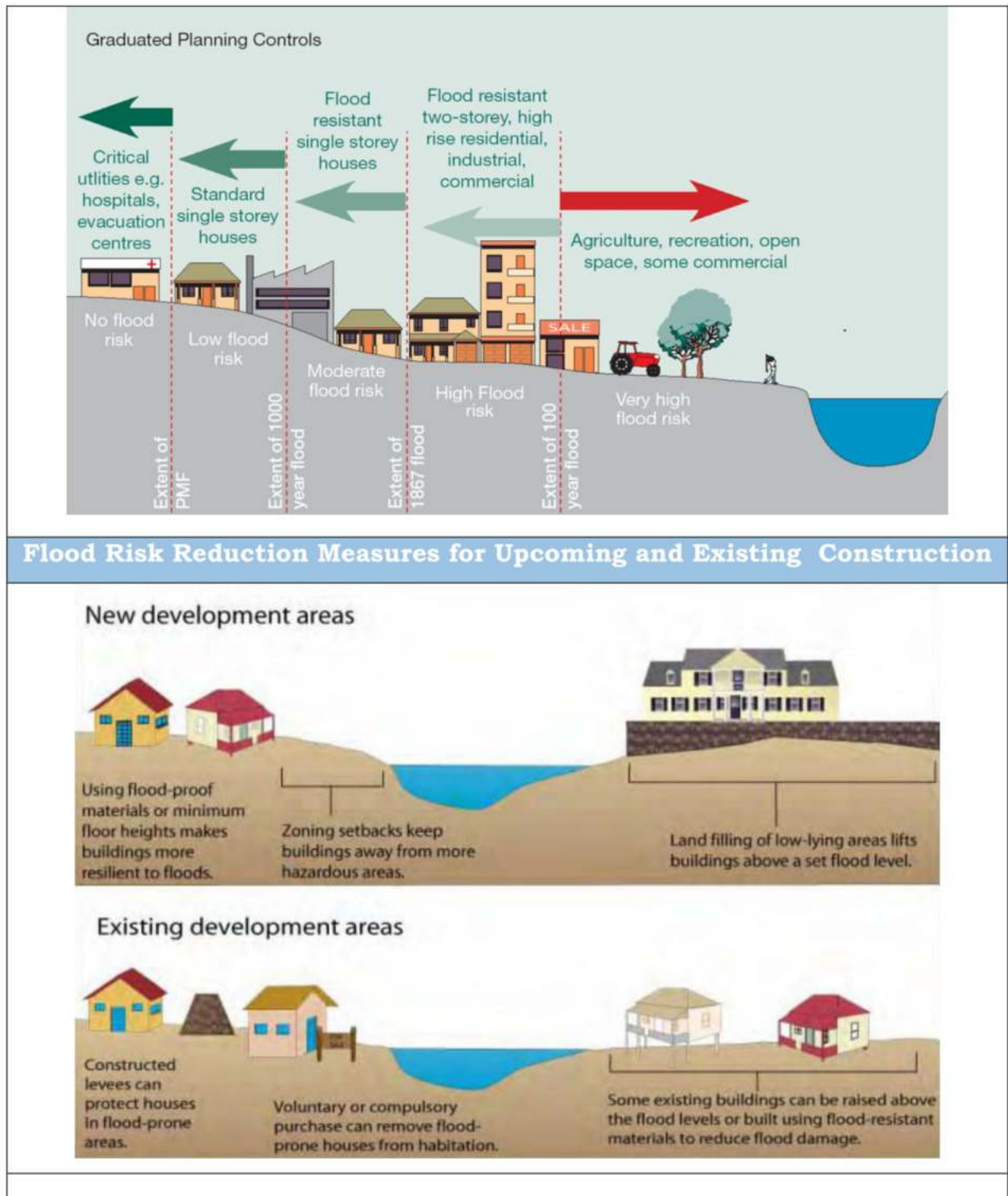


Figure 26: Snapshot of flood mitigation measures

Learning Unit 3.2: Non-structural Measures of Flood Risk Management

Non-structural Measures of Flood Risk Management:

Non-structural measures strive to alter the exposure to lives and properties from floods. It contemplates the use of flood plains judiciously, simultaneously permitting evacuation whenever the situation demands.

Non-structural measures play an important role in reducing not only the catastrophic consequences of residual risks but also adverse impacts on the environment.

Floodplain development, land use planning, flood forecasting & warning, flood-proofing, and assistance are the non-structural measures. However, non-structural measures should always be considered conjunctively in the planning and use of structural measures because of the potential for synergistic enhancement of their effectiveness.

Under some river basin conditions, the introduction of non-structural methods to limit flood damage may alone be more cost-effective than alternatively involving structural methods.

Non-structural approaches to flood management fall naturally into two categories:

1. Those *anticipatory measures* can be assessed, defined, and implemented in the flood plains to reduce the risk to property from identifiable potential floods
2. Those *planned emergency response* measures which are applied when a damaging flood is forecasted, imminent or underway, to help and mitigate its damaging effects

Non-structural Measures:

1. Flood Plain Zoning
2. Flood Forecasting
3. Control of flood plain development
4. Flood Insurance
5. Flood Proofing
6. Integrated Catchment Management

Flood Plain Zoning:

Flood plain zoning is to regulate land use in the flood plains to restrict the damage due to floods, while deriving maximum benefits from the same. The concept of zoning is very popular in the

assignment of town and country planning in which the area of a township is divided into residential, industrial, and commercial sectors with specification as to height, size, space, etc. But the notion of zoning of a flood plain is comparatively a newer one than the traditional types of zoning. Each river has a floodway of flood plain which is an area that will be flooded by the "greatest flood which can reasonably be expected for that region. It is the flood plain of a river that will enable it to discharge the waters of very high floods. Therefore, the flood plain must be kept free from encroachment by people to minimize the flood losses. The flood plain zoning is to be contrasted with other types of flood protection measures such as dams, levees, detention reservoirs, channel enlargement, etc. Compared to the latter methods of flood control, flood plain zoning is less expensive and is suited to the flood problems of certain regions.

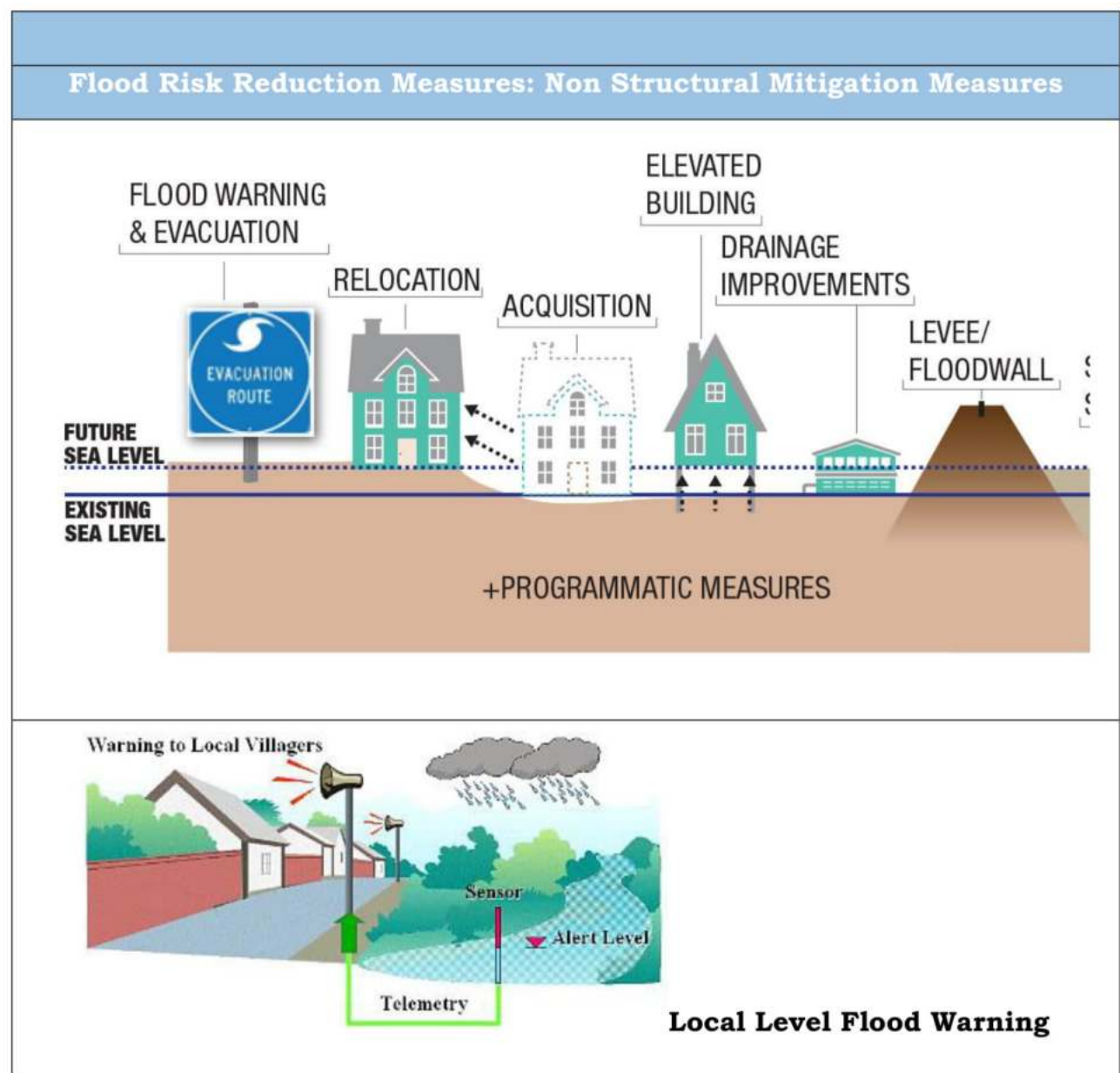


Figure 27: Snapshot of flood non-structural mitigation measures

Flood Forecasting:

Flood forecast is to issue warning about water level or discharge large enough that threatens the safety of structures and flood plain activities with longer or shorter lead times, depending on the drainage basins and hydro-meteorological parameters.

Flood forecasting can permit the prediction of the progress of floods, enabling the responsible authorities and involved populations to take personal, material, and organizational decisions to reduce the detrimental consequences of the imminent flood.

These decisions can range from *routine responses* (e.g. change of dam operation instructions, opening or closing of gates, anticipatory releases), to preventive instructions (barring navigation on the major flow channels, for example), up to *emergency measures* (announcing a generalized alert; mobilizing resources, evacuation and assistance for the population situated in high-risk areas, or ordering planned breaches of flood dikes).

The data most frequently used in flood forecasting (input variables) are:

- antecedent precipitation in the drainage basin
- soil saturation level in various points in the drainage basin
- streamflow at a point in the drainage basin upstream from the point of concern
- the snowpack and the temperature for basins which have snowmelt floods
- water storage capacity and levels in any reservoirs in the basin

Additionally, where appropriate to the basin size and to the flood forecasting time window, meteorological forecasts of risks, locations, and levels of predicted precipitation may also be incorporated. Normally, *flood forecasting is expressed with a prediction of the river "stage" or water level, or the discharge at the downstream point of concern.* It is very important to explain the *stages of warning* to the participants to make them understand the *language of the warning*.

Flood Forecasting by CWC:

The field units of the Central Water Commission located in various flood-affected states are responsible for issuing real-time daily flood forecasts for the various forecasting sites to the users.' At the Headquarter of the Central Water Commission, the "Flood Forecast Monitoring Directorate (FFM)" is responsible for monitoring the All India flood situation as well as daily flood forecasts and warnings issued by the field divisions every day. The FFM Directorate issues daily flood forecast monitoring bulletin comprising level and inflow forecasts along with complete analyzed data of each flood forecasting site showing the *degree of flood situation* in

terms of *water level* in respect of "Level Forecasting Sites" and *discharge volume* in case of "Inflow Forecasting Sites,".

In unprecedented and high flood situations,' three-hourly flood situations Ist levels of the concerned sites are also being collected through telephone, fax, wireless and subsequently special "Red" or "Orange" (renamed from Yellow) colored bulletins on latest flood situations are being issued by the FFM Directorate.

The special "Red" or "Orange" colored bulletins are being issued for drawing prompt attention of the concerned authorities towards the severe flood situations prevailing at that time in any part of the country.

Table 5: Flood Categories and Description

S. No.	Category	Description	State
1	IV	Low Flood (Water level between Warning level and Danger level)	Yellow
2	III	Moderate Flood (Water level below 0.50m less than HFL and above Danger: Level)	Yellow
3	II	High Flood (Water Level less than Highest Flood Level but still within 0.50 m of the HFL)	Orange
4	I	Unprecedented Flood (Water Level equal and above Highest Flood Level-HFL)	Red

Role of IMD & CWC in Flood Forecasting:

India Meteorological Department (IMD) issues *four types of forecasts* during the monsoon season i.e., *seasonal forecast* (for the whole season), *extended range forecast* (up to four weeks), *short-medium range forecast* (up to 7 days), and *nowcast* (up to 3 hrs).

Heavy rainfall events may lead to floods over different river basins of the country. River basin floods are dealt with the CWC. Flood Meteorological Offices (FMOs) operated by the IMD provide meteorological support to the CWC for issuing flood warnings about 146 river basins.

CWC issues flood forecasts for about 6 hrs. to 30 hrs. in advance for 176 stations using Quantitative Precipitation Forecast (QPF) received from FMOs and in-situ hydro-meteorological data.

To cater the services of hydro-meteorological events occurring in short duration of time, IMD is in the process of implementing a *Flash Flood Guidance System (FFGS)* shortly by which a diagnostic value within a watershed required to produce flooding at the outlet of the catchment

can be estimated, to support the flood warning services.¹⁶ Additionally, it can also provide, if feasible, an indication of the maximum expected level and its timing.

Floodplain Development

Floodplains are low-lying lands adjacent to waterways that are naturally subject to periodic flooding. The control of floodplain development requires a collective social commitment.

In flood plain development following points must be addressed:

- Reduce future potential for flood damage and loss of life;
- Determine and describe acceptable or compatible land uses within the designated floodplain, and (this is a key issue):
- Increase public and institutional awareness of risks associated with flood plain.

There are a variety of techniques that can be employed to regulate or control the types of development and uses within the floodplain. Some of these techniques include floodplain regulations; zoning and land use by-laws, subdivision regulations, building codes, development policies, and tax adjustments.

Flood Insurance

It is a type of risk transfer tool. Which may provide immediate and temporary relief to the loss caused by flood damage. Flood insurance covers direct physical losses from floods and losses resulting from flood-related damages caused by stagnation of water.

Flood insurance differs from the other tools for managing flood losses: whereas other tools reduce the cost of flood damage from each flood, insurance distributes the losses over time and space.

Insurance does not reduce the long-term cost of flood damage, it is often complementary to those flood-plain management strategies, which do reduce losses, such as, flood mitigation works, forecasting, flood-proofing, or changes in land-use to more flood-tolerant uses.

Flood-Proofing

Flood-proofing as "the modification of buildings and structures and their immediate surroundings to reduce damage in flooding." It limits flood-proofing to physical measures to avoid or minimize exposure to floods. As such the construction of buildings on individual earth mounds raised to the level of ordinary high floods and the use of easily dismantled materials for houses in flood-prone areas can be considered as flood-proofing. Flood proofing measures help greatly in the mitigation of distress and provide relief to the population in flood-prone areas.

Integrated Catchments Management:

Integrated catchment management is protecting land, water resources, native vegetation, and biodiversity. Over the past decade, the relatively new approach to conservation and sustainable use of resources - the integrated catchment management approach - has proven more holistic, recognizing that land, water use, and environmental impacts are inter-connected and that actions in a catchment have cumulative impacts on areas downstream.

It is a system-based approach, attempting to blend the objectives of environmental protection, sustainable agriculture, and natural resource management within catchments with the principles of ecologically sustainable development.

The approach provides a focus for translating national and state natural resource management strategies into coordinated and effective on-ground action. It is at this level of resolution that integration can achieve maximum synergies between primary production and biodiversity outcomes.

Integrated catchment management is also increasingly seen as critical to the coastal zone as nutrients, sediments and other pollutants arising from within catchments can have a significant impact on the health of coastal and marine ecosystems.

The approach also attempts to ensure all interested parties in a catchment (those involved in land use planning, natural resource management, primary production, conservation, and the community) work together in planning and implementing catchment management policies.

This holistic approach provides a more effective way than previous approaches to managing catchments. It maintains production and development activities in sympathy with the landscape's natural values.

Learning Unit 3.3: Flood Preparedness Measures and Checklist

Flood Preparedness Measures:

Activities and measures *taken in advance* to ensure effective response to the impact of flood hazards, including the issuance of timely and effective early warnings, temporary evacuation of people, and safeguarding property.

Flood preparedness is about *putting in place a set of appropriate arrangements in advance for an effective response* to floods.

Some of the commonly identified *flood preparedness activities* are:

- *Public awareness-raising* on flood preparedness, response and mitigation measures;
- *Stockpiling of emergency relief materials* i.e., food, fodder for livestock, emergency medicines, materials for temporary shelter, etc;
- *Installation of community-based early warning system* for issuance of timely and effective flood warnings;
- *Management of safe areas for temporary evacuation of people* and property from a threatened location;
- *Transportation to safe areas/ evacuation center*; Ensuring access to health and sanitation facilities; Conducting drills and rehearsals.
- The key to flood preparedness is to have a *clarity and agreement on the roles and responsibilities of relevant stakeholders* such as the government agencies, disaster management organizations, Red Cross, voluntary groups as well as community members. Such an arrangement is possible by forming a disaster management committee and teams at various levels to agree on a set of standard operating procedures (SOPs) defining what actions to be taken before, during and after floods.

A. Before Flood

- o The route to the nearest safe shelters is to be known.
- o The First-Aid Kit is to be ready with extra medication for snakebite and diarrhoea.
- o Strong ropes should be available for tying things.
- o A radio, torch and spare batteries are to be arranged.
- o Freshwater, dry food, candles, matchbox, kerosene etc. are to be stocked.
- o Umbrellas and bamboo arrangements.

- o Higher ground is to be selected for stay where people and animals can take shelter.
- o Flood warnings and advice may be easily obtained through radio and television.
- o We must keep vigil of flood warning given by local authorities.
- o Dry food and drinking water and warm clothes are made to be ready.
- o Emergency kit must be checked.

B. At the time of evacuation

- o Pack clothing, essential medication, valuables, personal papers, etc in waterproof bags to be taken to the safe shelter.
- o Raise furniture, appliances on beds and tables.
- o Put sandbags in the toilet bowl and cover all drain holes to prevent sewage backflow.
- o Do not get into water of unknown depth and current.
- o Lock your house and take the recommended or known evacuation routes for your area of safe shelter.

C. During Floods

- o Boiled water or the use of a halogen tablet to purify water.
- o Food should be covered.
- o Children should not be allowed to remain on an empty stomach.
- o Bleaching powder is to be used to disinfect the surroundings.
- o Entry in floodwaters may be avoided. If one needs to enter then proper footwear must be used.
- o Water over knee level may be avoided

D. After a Flood

- o One has to be in touch with local radio.
- o Children may not be allowed to play in, or near, floodwater.
- o One has to stay away from drains, culverts.
- o Electrical appliances should not be used.
- o Food contaminated by floodwater must be avoided.

Flood Preparedness Checklist@:**Table 6:** Flood Preparedness checklist

S. No.	Preparedness Measures	Yes / No
1	Have you identified the flood-prone blocks, talukas, tehsils, and villages?	
2	Is there a responsible officer-in-charge of relief and anti-disaster operations?	
3	Is there a clear division of responsibility for flood relief among the officers and the staff?	
4	Is there an operation control centre? Is there a roster of duties to run it round the clock?	
5	Is a logbook maintained to keep data about the rise of floodwaters at regular intervals of the rivers in the State?	
6	Is there a coordination committee for relief?	
7	Are the District level officers and Block level officers of health, Water Resources, Roads & buildings, Telephones and Police, represented on it? Do they meet at least three weeks before the onset of monsoon?	
8	Are the Sub-Divisional Officers and Block Development Officers of flood-prone areas invariably asked to attend the meetings? Are voluntary relief organizations having repute and standing and the district branch of Indian Red Cross associated with the committee?	
9	How is the flood warning communicated through mobile units and the flood-prone sub-division and blocks to issue a warning?	
10	Has the Deputy Controller of Civil Defence received any training on Disaster Preparedness?	
11	Has the Deputy Controller of Civil Defence trained the C.D. Wardens in this matter?	
12	Has the Home Guards been given any training in disaster preparedness for floods, as well as rescue/relief/first aid?	
13	Are the flood-prone blocks are well connected and transmissible with police?	
14	Mobile water tankers, canvas water tanks, drums, and Jerry cans for transporting water buckets are kept ready?	
15	Sandbag for repairs of flood protection embankment are kept ready?	
16	Basic field Sanitary Engineering equipment are available?	

17	<p>Has the Chief Medical Officer likewise checked up the stock of essential medicines, vaccines, disinfectants, first aid kits at the District/Sub-divisional medical store and kept the Primary Health Centres in flood-prone area well supplied with the following:</p> <ol style="list-style-type: none"> Disinfectants such as bleaching powder, chlorine liquid solution, water purifying tablets, phenyl (for ensuring quantity of free chlorine for supplying safe and potable drinking water). Essential medicines for mobile team and dispensaries in the evacuee camps are available? Are such stations having wireless set? Who is responsible for disseminating the flood warning at the village level? 	
18	Has the officer-in-charge of relief inspected the District/Sub-divisional Relief stores after the occurrence of floods?	
19	<p>In particular, has he checked the stockpiles of</p> <ol style="list-style-type: none"> Clothing (including children's garments) durries/mats? Tents, tarpaulin, G.C.I Sheets, and other materials for providing temporary shelters? Boats, power-driven and life-jackets? 	
20	Antidiarrheal, antibiotics, anti-malaria drugs, anti phytotics, analgesic and anti-allergic drugs choloresel I.V. fluids pediatric formulations for treatment of gastro informal and respiratory infections in children have been kept ready ?	
21	Have flood shelters (Schools, Community Centers) been identified ?	
22	Are the shelters easily accessible ?	
23	Are the shelters provided with sources of drinking water ?	
24	<p>What are the sanitary arrangements for these evacuation camps?</p> <ol style="list-style-type: none"> Deep trench latrines Temporary Urinals with soak pit. Incinerations for burning dry refuses. 	
25	Has the District Manager, Food Corporation of India checked up if sufficient stock of food grains are in position in the flood-prone areas of the District before the monsoon starts ?	
26	Has the Officer-in-charge of civil supplies ensured that the dealers keep sufficient stock of essential articles like pulses, edible oil, salt, milk powders, baby food, matches and lanterns before the start of flood season ?	
27	Have the whole-sale consumers co-operative societies, been requested to	

	keep in readiness the stocks of aforesaid articles at the branch level ?	
28	Have suitable sites for probable helipade on raised grounds in the flood prone area been located ?	
29	Has meeting of the Transport Operators been called by the Chairman of the Regional Transport Authority to negotiate with the former the placement of private vehicles at reasonable rates for evacuation of flood victims and movement of relief goods ?	
30	Have people in low lying area which have been inundated in every flood been alerted first by the flood warning ?	
31	Has the concerned block identified and kept in readiness in shelf of projects pertaining to relief works which can be launched when the flood water recedes ?	
32	Have the villages water-logged for a long time been identified ?	
33	Is there a list of people who cannot be provided with gainful work, but many have to be fed, freed at Government cost for some time ? Have the Panchayats been associated in preparing the list of such beneficiaries for gratuitous relief ?	
34	Have the people in flood prone villages been trained in relief and rescues?	

Technical Session 4

Flood Response Measures

Introduction

Flood response measure involves the rapid deployment of supplies and logistics with appropriate coordination mechanisms with local agencies, communities, and other agencies working in the affected areas to bounce back the situation in normal condition.

Objectives

The objectives of the session are to:

- ❖ Introduce the Flood Response Measures
- ❖ Discuss the essential components of Flood Response Measures (FRM)
- ❖ Case Study

Learning Units:

LU 4.1 Flood Response and Components of Flood Response

LU 4.2 Gujarat Flood Case Study 2017

Duration: 75 minutes

Suggested Methods

Interaction, Presentation, and discussion.

How to Conduct

- ❖ Ask the participants as to what do they know about Flood Response
- ❖ Discuss the different steps of flood responses
- ❖ Make a brief presentation.
- ❖ Invite questions and clarify
- ❖ points raised by the participants

Learning Unit 4.1: Flood Response and Components of Flood Response

Flood Response:

Management and control of the adverse consequences of flood requires co-ordinated and effective response systems at all levels, like State, District, Taluka, and Local Community.

Flood Response component must have the following background knowledge about:

1. The source and direction of the flood.
2. Weather events that may trigger flood and/or surface water inundation.
3. Estimation of the time (it would take for the site to be flooded from potential flood events.

From this, an estimation of the time required to put in place the response plans and actions).

4. The likely depth of water on the site and in low-lying areas (such as basements).
5. The flooding likelihood (this is usually the flood return level)
6. Estimation of how long water would remain in the facility,
7. Estimation of the potential costs of damage and the impact on business.

Flood response coordination must be ensured at the following time scale:

1. Before Flood Season (Every Year)
2. Before the Flood (On alert of imminent flood conditions)
3. After the Flood (Action immediately after the flood)

Pre-monsoon response mechanism ensures the site's Pre-Prepared Flood Emergency Plan, Local area flood protections structure are in good conditions (wall, levee & bridges are properly maintained and repaired timely), On-site flood protection features and equipment are functional, essential backup equipments like sandbags are available and lastly, all flood emergency team are fully briefed about the duties and responsibilities.

On alert of Flood: Person to monitor flood and communicate to officers are in proper functional communication network with all unfailing channels. Sandbags and de-watering equipments are ready, fuelled, and operational. Gas pipelines are safe & disconnected. Electric equipments and supply lines are shut down. External equipments are barricaded to prevent the damage due to debris, drainages are clear, fire protection equipments are ready to use.

After Flood: Convene a meeting to coordinate actions and salvage operations, check structural integrity and stability, clear up plan, deploy a specialist team to safeguard and restore electric

supply, ensure good workflow in the removal of wet debris, refuses and damaged materials, Check the condition of local structures that may have been affected or damaged by the flood e.g. blocked culverts, drains, bridges, overhead electrical systems, substations, maintain good communication channels.

Components of Flood Response:

Major components of Flood Response are as follows:

1. Estimation of Severity of Flood
2. Incident Response System
3. Emergency Action Plan
4. Specialized Teams for Response
5. Evacuation
6. Emergency Search and Rescue
7. Emergency Medical Response
8. Emergency Relief
9. Emergency Logistics
10. Community-based Disaster Preparedness and Response

Estimation of Severity of Flood:

The preliminary assessment of the severity of a flood should be based on the water level and the estimate of the area flooded. The flood control cell works round the clock during the monsoon period. The flood control cell collects the Gauge level of interstate rivers. The daily flood report, three hourly water levels of interstate basins, and hourly water level of schemes during floods are updated by online data entry. The flood cell also collects information on other major/medium projects. and inform officers of NWRWS&K and Revenue Department officers about the situation of floods in various rivers of the state. The Flood Control Cell, Gandhinagar also obtains the weather forecast and rainfall data, etc. from IMD/CWC, the water level and forecast convey in the morning after 8:00 A.M. to all concerned the same can be assessed from satellite imageries.

Incident Response System:

The Incident Response System (IRS) is all the tasks that may be performed during Disaster Management irrespective of their level of complexity. It envisages a composite team with various Sections to attend to all the possible response requirements. The IRS identifies and designates officers to perform various duties and get them trained in their respective roles.

Everyone will know what needs to be done, who will do it and who is in command, etc. IRS is a flexible system and all the Sections, Branches and Units need not be activated at the time of flood.

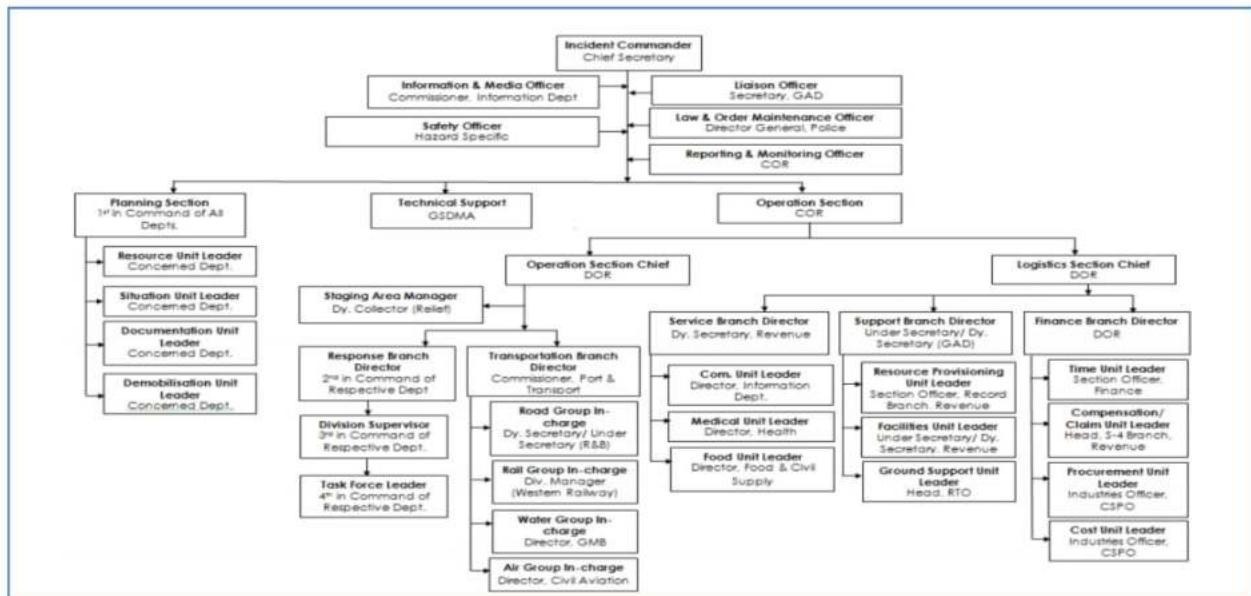


Figure 28: Incident Response System

Various Sections, Branches, and Units need to be activated only as and when they are required. The IRS organization functions through Incident Response Teams (IRTs) in the field. In line with our administrative structure and DM Act 2005.

Responsible Officers (ROs) have been designated at the State and District level as overall in charge of the incident response management. The ROs may however delegate responsibilities to the Incident Commander (IC), who in turn will manage the incident through IRTs. The IRTs will be pre-designated at all levels; State, District, Sub-Division, and Tehsil/Block. On receipt of Early Warning, the RO will activate them. In case a disaster occurs without any warning, the local IRT will respond and contact RO for further support, if required.

A **Nodal Officer (NO)** designated for proper coordination between the District, State and National level in activating air support for response. Apart from the RO and Nodal Officer (NO), the IRS has two main components;

- a) Command Staff and
- b) General Staff.

Meteorological Center and Flood Meteorological office stationed at Ahmedabad collects information regarding the meteorological situation of the State. The meteorological center also issues heavy rainfall warnings to those officers of NWRWS& Kalpsar Dept. and Revenue

Departments of Government of Gujarat. The government of India has set up two Divisions, Tapi Division and Mahi division for issuing flood warnings of six inter-state rivers viz. (1) Damanganga (2) Tapi (3) Narmada (4) Mahi (5) Sabarmati and (6) Banas.

The inflow forecast and flood level forecast for the above basins are to be conveyed to officers of the rank of Superintending Engineer or Collector of concerned districts or Municipal Commissioners, as Appropriate Authorities (Focal Officers) for various basins/regions during the monsoon period.

The Focal Officer can nominate any Executive Engineer/Officers in his area as his second in command who will act as Sub-Focal Officer for discharging duties of Focal Officer.

Keeping constant watch over the flood situation, flood warning, monitoring flood discharges through concerned project authorities, formulating flood forecast as and when required conveying these warning including conveying inflow forecast and flood level forecast from C.W.C. or the case may be in advance to the concerned Revenue and Police authorities for alerting and evacuating people of the area likely to be affected.

Control Room Set-up:

As a part of “Flood Warning Arrangement” a Flood Control Cell under the control of Superintending Engineer from 1st June to 31st October or up to one week after withdrawal of monsoon by I.M.D. The Flood Control Cell works round the clock during the monsoon period. The Flood Control Cell collects gauge levels of inter-State rivers viz. Damanganga, Tapi, Narmada, Mahi, Sabarmati, and Banas from Tapi and Mahi Divisions of C.W.C. and maintains up-to-date records of three hourly water levels during monsoon and hourly water levels during floods.

The cell also collects information of other Major/Medium Projects and informs the officers of the Narmada Water Resources, Water Supply & Kalpsar Department & Revenue Department.

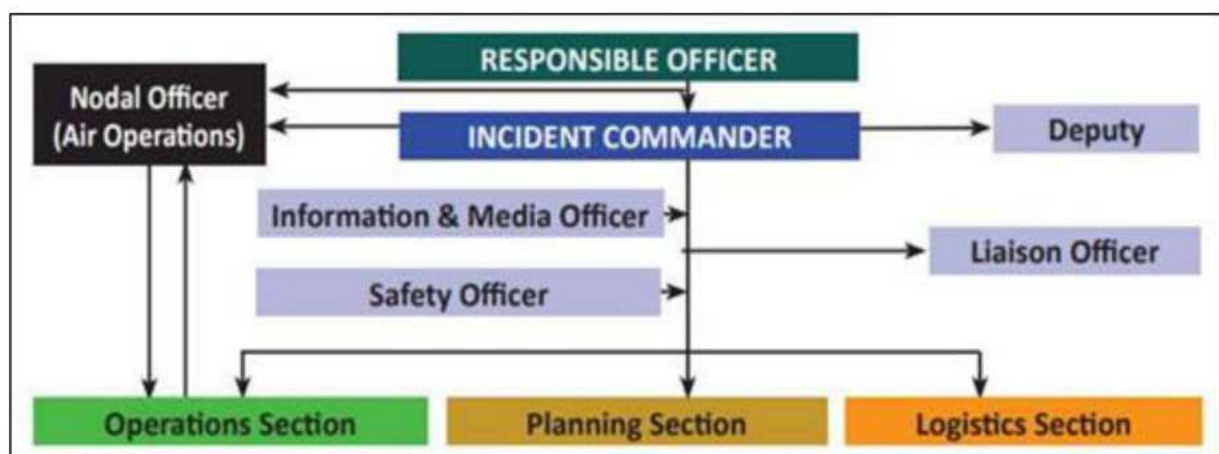


Figure 29: Incident Response System on site

In the event of any news items appearing in the newspapers regarding flood damages including inundation etc. in any area, the concerned Superintending Engineer should immediately take stock of the situation and issue necessary press release clarifying the actual situation.

Emergency Action Plan:

On receipt of flood warning, the revenue authorities will in turn take necessary actions for alerting and evacuating the people likely to be affected following warning as per Flood Memorandum.

Whenever heavy outflow is likely to be let off Focal Officer/Executive Engineer informs either to the Assistant Engineer of Railway or to the Station Master of the nearest railway station or Divisional Railway Manager.

In case, the warning is received by the Railway authority in time it will be possible to take preventive measures to regulate the running of trains & to protect the Railway property, staff, and passengers.

All concerned Focal Officers should prepare a drill to be followed during monsoon at the time of various floods including catastrophic flood and fix duties of all concerned persons at that moment. The rehearsal of this drill should be made before the onset of monsoon.

During emergency flood messages are also conveyed by Focal Officer or any officer authorized by him and Collector of the District to All India Radio/Doordarshan Kendra for necessary broadcast.

There are many drains in the state. These drains are linked up with inter taluka or inter-districts. Several drains are long and have a large capacity. Due to heavy to very heavy rainfall in the catchment areas of the drain, the drains cause damages to land, crops, property, cattle of the adjoining areas. The Executive Engineer, in charge of the drain, has to function as a “FOCAL OFFICER and Dy. E.E. a sub-focal officer have to take necessary action and make efforts to control the situation.

Sub-Focal Officer-in-charge of the drains has to intimate his higher authorities and revenue authorities like Mamlatdar, Prant Officer, Collectors, Police Authorities, Home Guard Authorities regarding the situation.

All authorities are requested to extend the help required by the sub-focal officer to overcome the situation.

Specialized Teams for Response:

National Disaster Response Force (NDRF):

National Disaster Response Force established to provide a specialized response to any threatening disaster situation or disaster. At present, NDRF comprise of 12 battalions, with each battalion consisting of 1149 personnel. All the 12 battalions are located in Assam, West Bengal, Odisha, Tamil Nadu, Maharashtra, Gujarat, Uttar Pradesh, Punjab, Bihar, Andhra Pradesh and Arunachal Pradesh. Each of these battalions have 18 teams with high skill training and the latest equipment for water rescue. To ensure prompt response to any flood situation, each of these battalions also has Regional Resource Centres (RRCs) in high vulnerability areas, where boats and other water rescue equipment pre-positioned.

The NDRF units maintain close liaison with the state administration and available to them proactively, thus avoiding long procedural delays in deployment in the event of any serious threatening disaster situation. The NDRF battalions provided with communication equipment for establishing last-mile connectivity. Battalion 6th is active in Gandhinagar, Gujarat.

State Disaster Response Force (SDRF):

State has its own State Disaster Response Force responding to disaster in the state. The existing eleven flood relief State Reserve Police Force (SRPF) companies trained to handle various kinds of other disasters on the line of NDRF and they have designated as State Disaster Response Force (SDRF) companies. They will have deployed in affected areas during various kinds of disasters as per the requirement of Commissioner of Relief (COR) while during the rest of the year; when there is no disaster situation they will be deployed for Law & Order duties by the Director-General and Inspector General of Police, Gujarat State.

Fire & Emergency Services:

Fire service is one of the most important emergency response services in the country, which comes under the 12th schedule of the constitution dealing with Municipal functions. At present, fire prevention and firefighting services are organized by the concerned States and Union Territories (UTs), and Urban Local Bodies (ULBs). The primary role of fire services has been to attend the fire incidents. Besides firefighting, fire department also attends to other emergencies such as building collapse, road traffic accidents, human and animal rescue, etc., Various states have also formulated State Disaster Management Authorities (SDMA"s) and District Disaster Management Authorities (DDMA"s) both of which consider Fire Service as an Emergency Support Function (ESF). The role of Fire Services has become multi-dimensional that includes not only attending fire incident calls but also various other emergencies.

Emergency Services of 108:

108 is a free emergency telephone number in twenty five States & Union Territories of India. When an emergency is reported, the call taker gathers the needed information and dispatches appropriate services within an average of 18 minutes. For the medical emergency in a disaster situation.

State Police:

In case of any disaster situation state uses state police department for law and order maintenance and to help in the search, rescue, relief, and other required services by the state.

Aapda Mitra:

Aapda Mitra is community volunteers. They are trained for conducting basic search & rescue operations and to assist the district administration for effective disaster response. It is planned that 6 *Aapda Mitra* would be trained from each District and Taluka. The fully residential training would be conducted at the 11 designated training centers of SDRF/SRPF. The duration of the training would be of 2 weeks. At the end of the training, they would be certified as '*Aapda Mitra*' by GSDMA and also provided with an identity card for the same. The '*Aapda Mitra*' shall remain present for assistance during any emergency.

Home Guards:

The Home Guards serve as an auxiliary manpower for the police force and support the district administration in various tasks. They are trained for carrying out search, rescue and relief operations in disaster situations.

Civil Defence:

Civil Defence (CD) organization into disaster management works as a great catalyst for organizing community capacity building. CD recruited and trained personals. CD has its coverage to all the districts in the country and assigning; it an important role in the DM framework, the primary role of CD is community capacity building and creating public awareness in the pre-disaster phase.

Flood Response Measures:**Evacuation:**

Evacuation of the human population and livestock is the only prescribed means to save them from the fury of floods. Evacuation of flood-affected communities can be one of the most difficult response operations, especially, when it involves a large population.

Evacuation needs to be carried out as a precautionary measure based on warning indicators, before impact, to protect flood-threatened persons from the full effects of the disasters.

Evacuation may also be necessary after the area has been flooded to move persons from a flood-affected area to safer areas and better surroundings. For carrying out successful evacuation, the threat perception on the part of DM officials is essential. Continuous dialogue with stakeholders such as early warning providers, transportation authorities, health-care authorities/ personnel, food, and essential commodity suppliers, civil societies, NGOs and last but not the least, the communities including the Decision Support System (DSS) and inputs based on Geographical Information System (GIS) platform are essential for carrying out successful evacuation.

Emergency Search & Rescue:

Community-level teams develop in each district with basic training in search and rescue by the NDRF/SDRF. NDRF/SDRF battalions imparts training and assist the state government/district authorities to train communities. Communities further assisted by the ATIs, CD, Home Guards, and NGOs. The state governments, through the ATIs, develop procedures for formally recognizing and certifying such trained search and rescue team members; they provide suitable cover to community-level team members for their actions in the course of emergency response during the flood.

Emergency Medical Response:

Prompt and efficient emergency medical response provisioned by Quick Reaction Medical Teams (QRMTs), mobile field hospitals, including floating hospitals for riverine islands and areas inaccessible by roads, Accident Relief Medical Vans (ARMVs) and heli-ambulances become activated to reach the flood-affected areas immediately, along with dressing material, splints, portable X-ray machines, mobile operation theatres, resuscitation equipment and life-saving drugs, etc. Resuscitation, triage, and medical evacuation of victims and admission who requires hospitalization get activated.

Emergency Relief:

The Emergency relief services are delivery services that fetch immediate basic needs at time of crisis. majority of the activities covers are distributing relief among the affected people, identifying missing people, and addressing the needs of health care, water supply and sanitation, food, etc. Members of the teams aware of the specific requirement of the disaster-affected communities. It will be ensured by the concerned authorities that the stockpiling of the essential commodities have been carried out. These teams will also assist the government in identifying the most vulnerable people who may need special assistance.

Taluka Level Model Action Plan:

1. Identification of the flood-prone talukas
2. Setting up an operation control center and ensure duties to run it round the clock.
3. Maintaining a logbook to keep data about the rise of floodwaters at regular intervals of the rivers in the State, ensuring coordination committee for relief
4. Flood warning communicated through mobile units and microphone in the flood-prone sub-division and blocks to issue warning
5. Readiness for being mobilized at short notice
6. Flood prone blocks connectivity with the telephones and police network

Emergency Logistics**Equipments:**

Motor launches, country boats, inflatable rubber boats, life jackets, lifebuoys, and other equipments require immediately after floods to carry out search and rescue of trapped people. State governments compile a list of such equipment, identify suppliers thereof and enter into a long-term agreement for their quick mobilization and deployment whenever required. The IDRN, which is a web-based resource inventory of information on emergency equipment and response personnel available in every district, will also be used for this purpose. The information on IDRN should be updated.

Community-based Disaster Preparedness and Response:

NGOs, self-help groups, CBOs, youth organizations such as NCC, NYKS, NSS, etc., women's groups, volunteer agencies, CD, Home Guards, etc. normally volunteer their services in the aftermath of any disaster. Village level task forces constitute voluntarily for better preparedness of the community.

Relief Camps:

Relief camps are shelter for displaced people in a disaster situation. The provision of basic amenities in such camps involves complex logistics of mobilizing relief supplies, tents, water supply, sanitation systems, transport, communication systems, and medical supplies.

A minimum standard of relief guideline lay down by the NDMA under Sect.-12 of Disaster Management Act-2005. Where Minimum standard in respect of Shelter, Water, Sanitation, Medical cover, relief for widows, and Orphans has been mentioned under Sect. 19. For this state shall lay down standard.

Debris Clearance after Flood:

To start the essential services, it needs to clear the debris generated by the disaster.

Table 7: Debris generated by various disaster situation

Disaster Type	Damaged Buildings	Sediments	Green Waste	Personal Property	Ash and Charred Wood
Hurricane	✓	✓	✓	✓	
Earthquake	✓	✓	✓	✓	✓
Tornado	✓		✓	✓	
Flood	✓	✓	✓	✓	
Fire	✓			✓	✓

Flood generates muds, sand, earth material, construction material, green materials, and some household goods and articles that get deposited on roads, and chokes the drainage system. The refuse must be clear on a priority basis to restore the normalcy and start the supply of the essential services.

Example: As massive scale clearance of debris completed by the team in Gujarat during 2017 flood, which included 466 sweepers and 36 managerial staff of Surat Municipal Corporation and Vadodara Municipal Corporation, by using 33 tractors, 70 JCBs, 2 loaders, 3 de-watering pumps, 3 Hitachi Machines, 8 Jetting Machines, 5 Super Sucker Machines, 2 Mud Pumps, 2 Fire tenders, 7 fogging machines and 64 dumpers. Further, 17 metric ton of Malathion Powder was sprayed. A total of 7,651 metric tons of solid waste and 16 lakh liters slurry were disposed off. Hundred percent of residential areas were cleaned with the help of tractors and JCBs by 7 Health and Sanitation Teams.

Build Back Better:

Reconstruction in the post-disaster phase considers building back better. The new construction post-disaster should comply with all safety norms, guidelines, and building codes that are the lessons from past disasters. The design of these buildings should be disaster resilient as per the hazard profile of the state. Govt. of Gujarat shall monitor the reconstruction process and ensure that the principle of build back better is followed through disaster resilient reconstruction.

Community Level Flood Risk Management Approach:

Communities' mobilization for local flood-mitigation initiatives should, first of all, be recognized in each specific context. There could be many – and strong – differences, depending on the factors/issues. Prior to any other action, information needs to be assembled and analyzed in order to map natural, social and economic factors, community institutions concerned, etc.

Second step could be the formation of community-based flood management committees (CFMCs). A CFMC helps to increase the effectiveness of community-based FEWS. It is an integrated system of tools and plans to detect and respond to flood emergencies that are prepared and managed by the communities. The objectives of community-based FEWS are to manage fluvial flood or flash flood risk by providing early warnings to downstream communities and to enhance cooperation between upstream and downstream communities in the sharing of flood information.

Community-based FEWS are implemented in communities under flood risk to enhance the capacity of local people to withstand the adverse effects of floods or flash floods. A properly designed and implemented system can save lives and property by providing time for downstream communities to prepare, and respond to, the threat of flood.

While implementing the community-based FEWS, four key elements must be considered¹⁷:

- (a) risk knowledge;
- (b) monitoring and warning service;
- (c) dissemination and communication; and
- (d) response capability.

Information needs to be assembled and analysed to in order to identify the role and responsibilities of the CFMC, the CFMC formation process and the mobilization of community members, as well as the resources. The added benefits of the community-based approach should be identified and disseminated to the stakeholders concerned (including local-level authorities and political leaders, teachers and community leaders).

CMFCs perform various functions such as:

- Identification of risks to communities;
- Assessment of needs and capabilities of the community;
- Provision of equipment and supplies for emergency situations;
- Awareness-raising;
- Information dissemination and capacity-building;

- Networking, monitoring and reporting;
- Establishment of institutional building and linkages;
- Planning and interface with government institutions for rescue and evacuation, flood proofing and flood moderation;
- Conducting simulation exercise/drills to facilitate effective evacuation;
- Development of linkages with other communities and with government and external development partners (including the private sector);
- Monitoring, evaluation and record-keeping;
- Management of information for future reference
- Resource mobilization.

Community Level Response Measures during Flood:

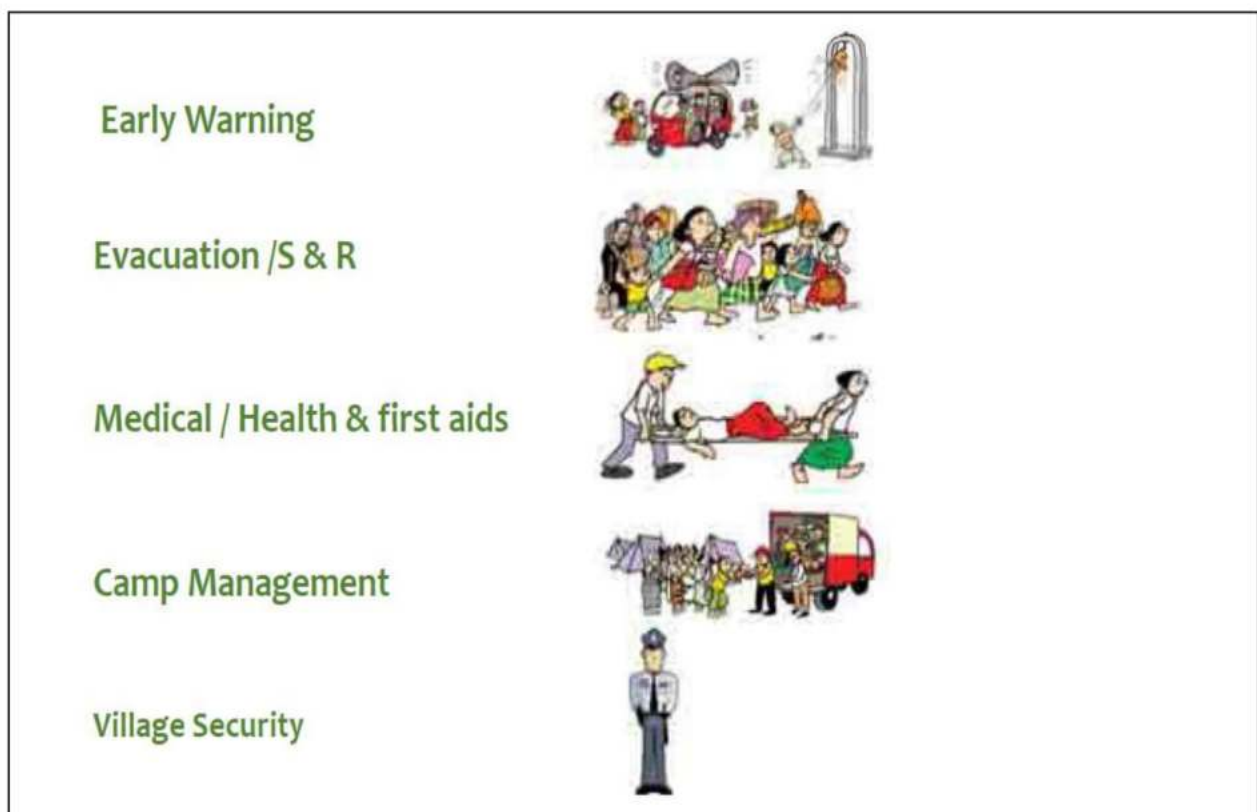
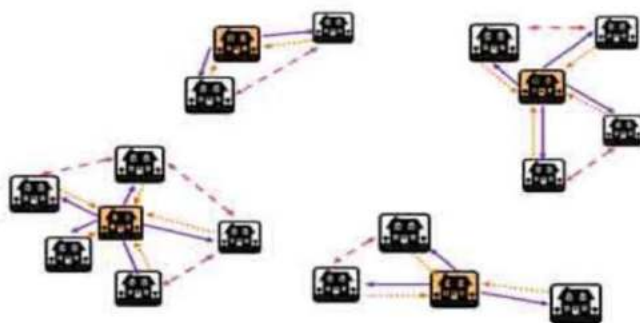


Figure 30: Flood Early Warning

Community Based Early Warning Sysytem with Simple Rain Gauge in vulnerable areas of the Community



- ❖ Information from Key House to neighboring house
- ❖ Checking with the Key House by neighboring house
- ❖ Information sharing paths between neighboring houses

Figure 31: Community based flood early warning system

Early Warning Dissemination System

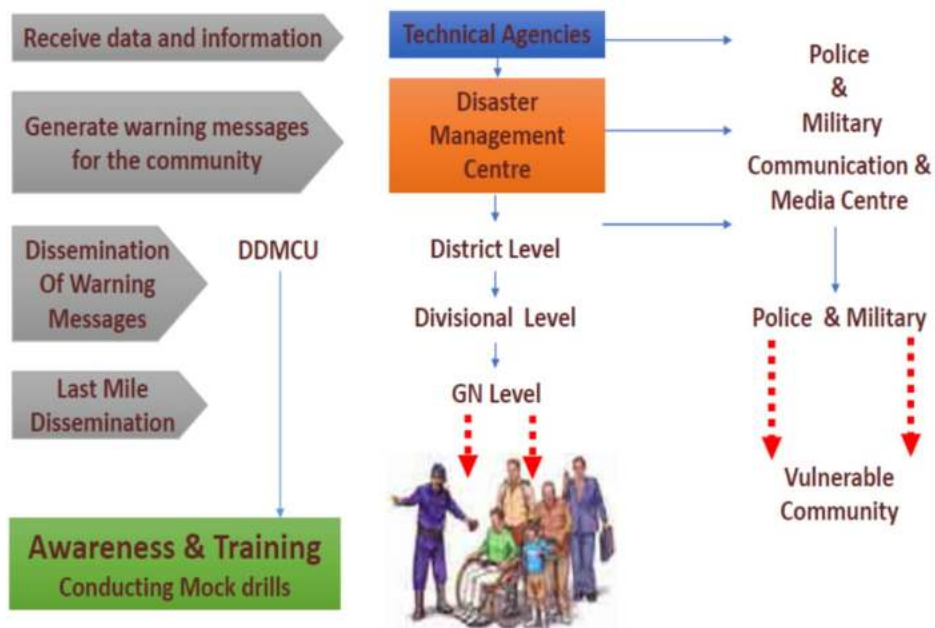


Figure 32: Early Warning Dissemination System

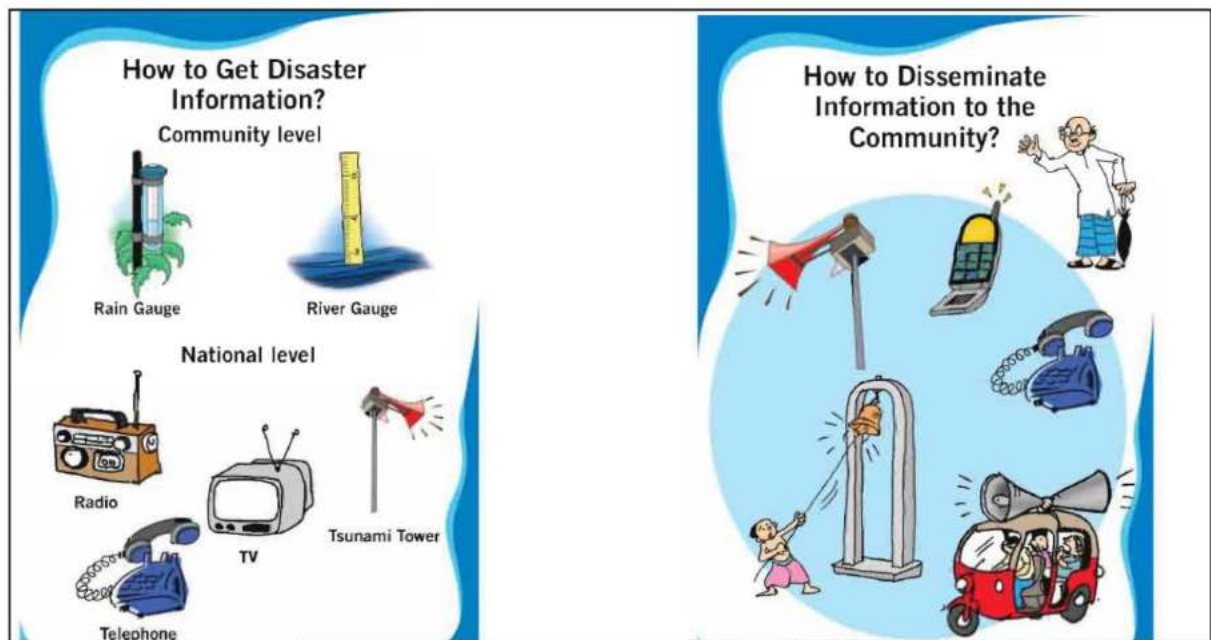


Figure 33: Community bases Early Warning Dissemination Devices

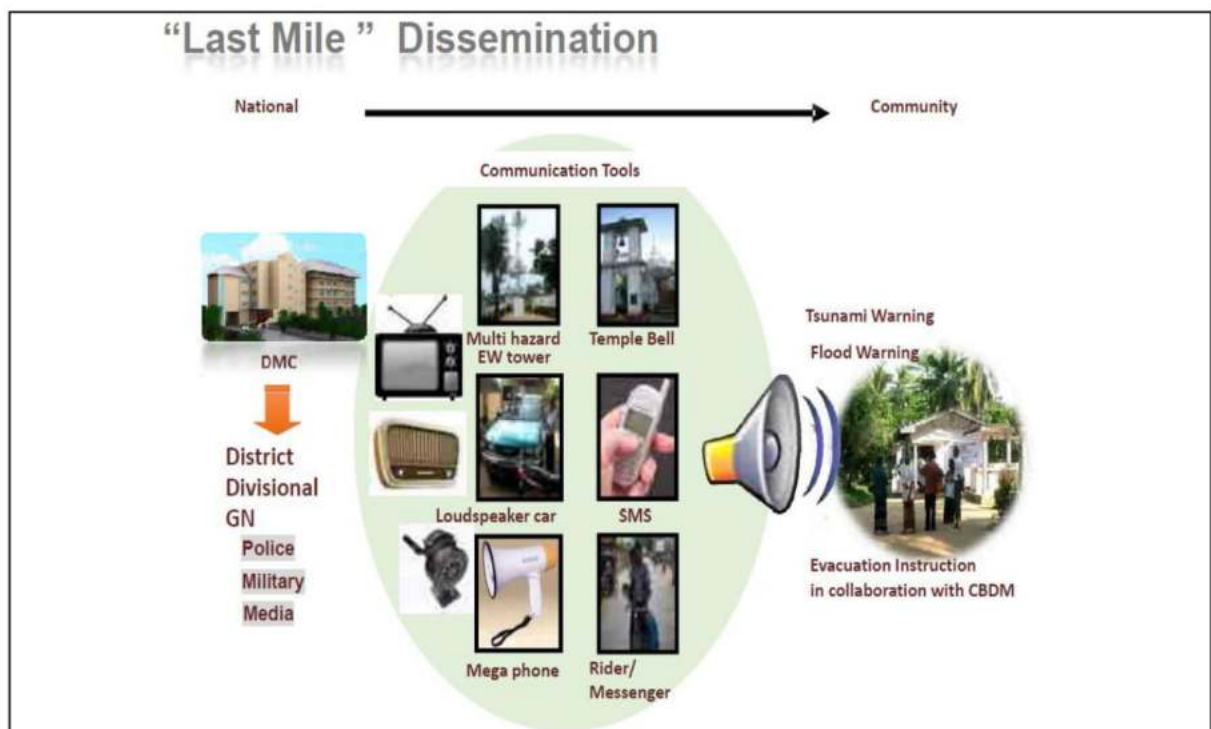


Figure 34: Community Based Early Warning Last Mile Dissemination

- Be vigilant during bad weather periods
- Be ready to evacuate with the first warning
- Send vulnerable people to safe houses sick, elders, infants, disabled.. Etc..
- Keep valuable property safe, out of the reach of water
- When evacuation is proclaimed, move away from the premises immediately with valuable documents, cash & valuables, essential medicines, minimum linen, infant food items, torch, pocket radio, mobile telephone (Take your Disaster pouch)etc..
- Listen to radio for further warnings
- Walk out of the way of water (better not to use vehicles)
- Move in teams, not alone
- Never try to cross water
- Very Important **Help to each other..**

Learning Unit 4.2: Gujarat Flood Case Study 2017

Gujarat Flood Case Study 2017:

Unprecedented rains lashed major parts of Gujarat in the 3rd and 4th weeks of July 2017 with the development of a low-pressure zone. The districts of North Gujarat along with Banaskantha, Patan, and Surendranagar were the worst affected.

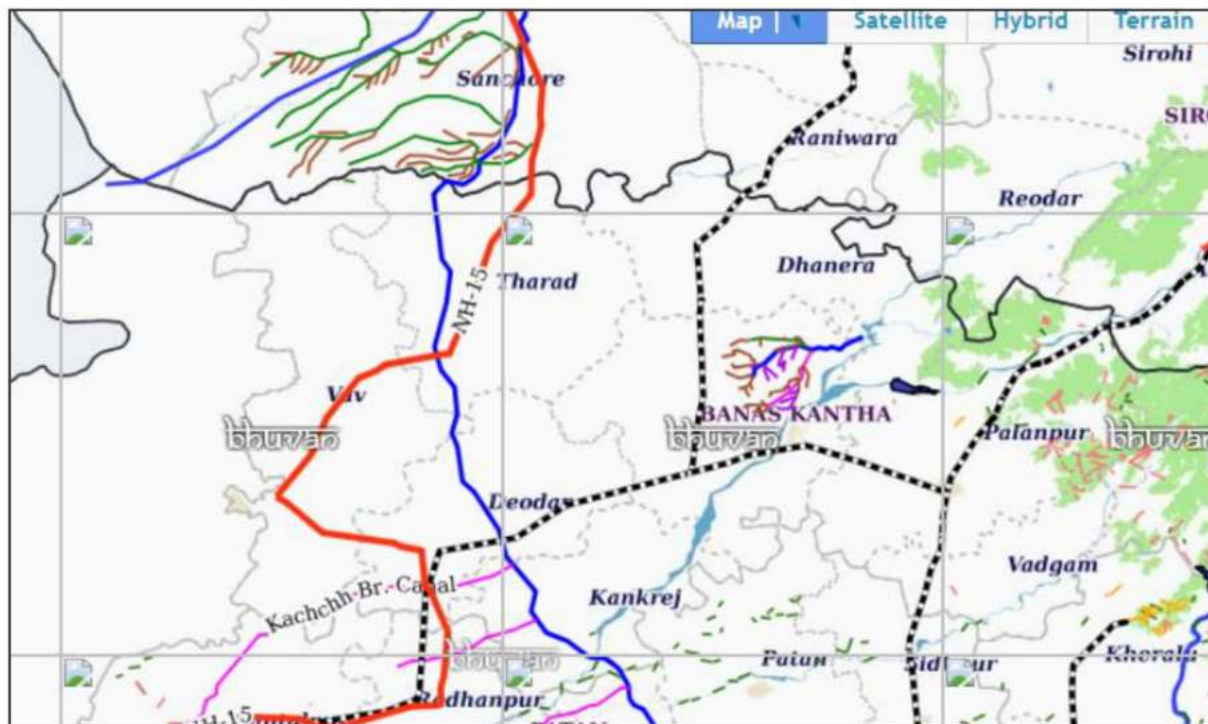


Figure 35: Snap view of Banaskanth Flood 2017

Loss Assessment by Government of Gujarat

- Road connectivity was badly disrupted due to continuous rains and cases of over topping thus disrupting transportation on many panchayat and state roads. More than 400 panchayat roads and 120 state roads were affected in the districts of Banskantha, Kutch, Mehsana, and Patan.
- As many as 2486 villages suffered power failure. Telecommunication was also adversely affected due to continuous rains and damage to communication infrastructure. More than 800 villages suffered majorly with communication failure.
- More than 100 schools have been damaged due to floods. Books and school infrastructure like cupboards were been damaged.
- 03 Civil hospitals lost crucial equipment like CT Scanners and diagnostic labs due to flood water damage. Ramps in old hospitals are broken creating issues for patient evacuation. Around 10 CHCs went non-functional.

- Water supply has also been disrupted in the affected districts. 1234 villages in Banaskantha, 880 in Kutch, 517 in Patan have been affected by water supply disruption.



Figure 36: Snapshot of Banaskanth Flood 2017

- Land loss of around 1450 hectares is reported in Patan district alone. Crop damage in 1972 hectares in Patan is reported so far. The survey work is on in other affected districts
- Cattle population along with wild life animals were found dead in the district. Total of 3778 cattle, in which 867 cows, 475 buffalos, 82 bullocks, 2211 sheep and goats and 143 other animals were found dead in different parts of the district far away from their place of habitat. Similarly, wild animals were impacted as Blue Bull (Neelgai) – 127, Cheetal- 7, Deer – 4, Lion – 3 (1 male, 2 female) found dead in non-reserved areas of district.



Figure 37: Snapshot of Flood Devastation 2017

- Railway network was severely affected by flood in Broad gauge line between Vav to Tharad was damaged. A major railway bridge was also severely damaged by floods.



Figure 38: Snapshot of Flood Devastation 2017

Preparedness Measures by State Government:

- a. Updation of District Disaster Management Plans
- b. The government of Gujarat has constituted a Weather Watch Group which meets every week during the monsoon season. This group collects information, interprets it and subsequently disseminates it
- c. State government was also in continuous touch with the India Meteorological Department (IMD) to keep a watch on weather conditions and rainfall
- d. Based on the IMD forecast, State Government prepositioned teams of NDRF, SDRF, Fire & Emergency Services, etc. in the districts as a precautionary measure. State Government also requested Army, BSF and Air Force to be ready for deployment in case of need

Media Handling:

- a. The govt. published a combined list of these Twitter accounts to enable people to reach out to the district administration in disaster situations.
- b. Four WhatsApp groups - Revenue Department, Crisis Management, Crisis Core, and Gujarat Rescue (Gujarat Govt. and Defence Forces) - were formed.
- c. Two Press briefings were held daily- one in the morning and other in the evening at the State Emergency Operation Centre.

Rescue Operation:

- a. Gujarat Government also appreciated the work done by NDMA on social media. “Do’s and Don’ts” for preparedness and response to various disasters is a good initiative for awareness generation
- b. On the very first day, a meeting of senior-level officers of all agencies that were to be engaged in rescue operations (e.g., Army, Air Force, NDRF, SDRF and Coast Guard) was organized



Figure 39: Rescue operation during flood

- c. Army set up base camp hospitals in Dharah, Kankrej with the help of State administration
- d. Ten NDRF teams were normally stationed in Gujarat (Five each in Ahmedabad and Baroda). Eight teams reached via rail from Pune Battalion
- e. As the situation became even more grave, 14 more NDRF teams were flown in from Delhi, Mundi and Arakonam
- f. Two deliveries were managed with the help of the Air Force
- g. Lack of equipment was a concern. Equipment made available to Municipal Corporations through GSDMA and additional boats received from NDRF were provided to SDRF personnel. They did a commendable job despite a shortage of equipment
- h. Rescue operations were phenomenal. At least 18,000 people were rescued. Of these, 7,000 were saved by NDRF followed by Army and Air Force
- i. Volunteers also acted as first responders. However, there is no trained volunteer network available in the State for an organized response
- j. Several damage and destruction in Banaskantha and Patan were reported during these floods, because these districts *received almost a 100 percent of their annual rainfall within 4-5 days.*



Figure 40: Rescue operation during flood by NDRF/SDRF

Relief Work:

- a. Normally, relief operations begin only after the floods recede as the entire administrative machinery is involved in rescue operations
- b. Both rescue and relief operations were conducted simultaneously (Immediate relief included moving people into safe shelters, arrangements for essentials like food, water, medicines, etc.)
- c. The cash doles were deposited in the bank accounts of the beneficiaries under the DBT (Direct Benefit Transfer) scheme
- d. Free distribution of fodder for cattle was also undertaken, Cattle assistance was enhanced from Rs. 30,000 to Rs. 40,000 for each cattle loss
- e. Hardly 10-15 % farmers had crop insurance, all insurance companies to streamline the process of settling, insurance claims
- f. Separately, crop assistance was provided under NDRF/SDRF norms
- g. Electricity Bill for farmers was also waived off for three months
- h. State Government declared a special relief package of Rs.1500 Crores for severely affected Banaskantha and Patan districts. Key highlights of the package are as under:
 - Rs.1336 Crore for Agriculture and land reform
 - Waiver of Rs.50 Crore towards electricity bills of farmers affected for three months
 - Rs. 20 Crore for financial assistance in case of loss of livestock
 - Rs. 15 Crore for trade, commerce and industries
 - Rs. 79 Crore for the schemes for relief measures of Revenue Department
 - Revised from Rs.6800/- to Rs.10000/- for crop loss in non-irrigated area
 - Revised from Rs.13500/- to Rs.20000/- for irrigated area
 - Revised from Rs.12800/- to Rs.25000/- for land erosion

Revised from Rs.60000/- to Rs.80000/- for severe land erosion

Assistance in Cash of Rs.75000/- for affected permanent large cabin shop holder

Assistance in Cash of Rs.15000/- for affected permanent small cabin shop holder

Assistance in Cash of Rs.5000/- for affected moving shop on trolley holder

Waiver of interest on a bank loan of up to Rs 10 lakh for two years to the merchants having monthly turnover of more than Rs.5 Lakh

Cattle Grass Distribution at free of cost:

- a. The grass in total quantity of 8,69,510 Kg distributed in Banaskantha by availing it from Dahod. 42,520 kg grass was supplied to Patan from Rajkot. Morbi and Maliya talukas were provided 1,26,750 kg grass despatched from Bhavnagar

Speedy Restoration of Essential Services:

- a. 836 roads were restored out of 952 roads for smooth transportation; total length of damage roads 15,048 Kms
- b. Restoration of electricity supply in 609 villages of Banaskantha district and 208 villages of Patan district
- c. Water supply started in 568 villages out of 712 affected villages of Banaskantha district. Water was provided in 144 villages through water tankers. Similarly, water supply started in 205 villages out of 328 villages of Patan district. Water has been provided to 108 villages of Patan district through water tankers
- d. All 2281 trips have been started in Banaskantha district and 2277 trips of Patan district by State Road Transport Corporation.
- e. Sanitation: Disposal of stored water and removal of mud, disposal of dead animals, complete cleanliness and preventive measures to prevent an epidemic.

Use of Drones - New Initiative Adopted:

- a. Some people were stranded at Surendranagar for about 24 hours and rescue agencies were also not able to rescue them. Drones were used to supply food packets, water, blankets, and a mobile phone with SIM to keep communication open.

Lesson Learnt:

1. Suitable institutional arrangements should be made between Gujarat and Rajasthan to improve preparedness for any probable flood in Banas and Sipu rivers as the two States share the catchment areas of both the river systems

2. Formation of high-level Expert Committee for the Dantiwada dam on Banas and Sipu rivers. This committee in consultation with the State government should take decisions on-site to appropriately regulate and release water from upstream lakes/tanks keeping in view hydrological and meteorological forecasts issued for the region.
3. During heavy rainfall, this committee with information to the State Governments may take decisions on releasing water from lakes/ tanks/ water bodies after reviewing the inflow forecasts
4. Training Walls should invariably be designed as Reinforced Cement Concrete (RCC) structures instead of coarse rubble masonry as practiced in the earlier construction. Coarse rubble masonry may not withstand heavy flood as was experienced in case of Dantiwada dam during 2017 floods
5. Gujarat adopted and identified Municipal Corporations as regional rescue centers and mandated therewith one of their regular activities so that they can operate functionally during any crisis. Such association helped during the floods in Gujarat. Similar practices may be replicated by other States
6. Regular monitoring of flood preparedness in the vulnerable areas, collection and compilation of post-disaster data, documentation of best practices, and lessons learned has to be done by the state/ district(s). This can further be used for capacity building activities. ¹⁸

Post Technical Session: Valedictory Session

At the end of the training, evaluation of the knowledge, skill, and attitude of the participants would determine their exit behavior. Knowledge and skill given through the training has to be evaluated. Feedback from trainees regarding the training, training module and related facilities would help in modifying future program/modules to make it more effective.

The Primary objectives of the module are :

- To understand the role of the NWRWS&K department in addressing flood both as part of a solution as well as building resilience against the impacts in the local and global context.
- To explain the uses of technology and modern innovations for reducing flood disaster risk and promoting sustainability.

Objectives

- To discuss a framework for flood risk reduction
- To evaluate the quality of training imparted through the program
- To assess the exiting behavior of the participants at the end of the course
- To evaluate the knowledge and skills gained during the course
- To carry out formal internal evaluation

Duration: 60 mins

Methodology

Anyone of the following methods can be followed:

1. Formal structured questionnaire – Each trainee is asked to fill up a structured questionnaire that evaluates their knowledge gained through the course.
2. Quiz on the course – Divide into groups and give points for correct answers. The group that wins gets a small prize.
3. Informal discussion–Identify the key learning points of the training and write it on a flip chart. After they finish, they move on to the next flip-chart and add or comment on the points raised by other groups. At the end of the exercise, all the points are collated by the trainer and discussed.

Training/ Performance Aids

Depending on the methodology chosen:

- Copies of pre-decided questionnaires or
- Flip charts, Markers, Tag-boards to pin the handouts

This successfully concludes the “Training Programme on Flood Risk Mitigation and Management”.

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Gujarat Institute of Disaster Management

Koba-Gandhinagar Road, Village Raisan, B/h Pandit Deendayal Petroleum
University, Raisan, Gandhinagar—382007, Gujarat, India.

Ph. (079) 23275804 to 25 | Fax: (079) 23275814

Email: info-gidm@gujarat.gov.in | Website: www.gidm.gujarat.gov.in