सत्यमेव जयते

Training Module

on

Management of Cyclone Disasters

nidm

Resilient India - Disaster Free India

National Institute of Disaster Management

(Ministry of Home Affairs, Government of India)

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National Institute of Disaster Management
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Training Module on Management of Cyclone Disasters

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Resilient India - Disaster Free India

राजेन्द्र रत्नू, भा. प्र. से.
कार्यकारी निदेशक

Rajendra Ratnoo, IAS
Executive Director

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

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FOREWORD

India's vulnerability to cyclones and associated hazards is amplified by several factors: a lengthy coastline spanning approximately 7,516 km, predominantly flat coastal terrain, a shallow continental shelf, dense population centers, and specific geographical and physiographical features. Situated within the North Indian Ocean (NIO) Basin, India is extremely vulnerable to cyclones and their associated hazards such as storm tides (resulting from the combined effects of storm surge and astronomical tide), high velocity winds, and torrential rains. A considerable number of these cyclones have their initial genesis over the Bay of Bengal and strike the East coast of India.

Every year on an average, five to six tropical cyclones form, of which two or three could be severe. Cyclones occur frequently on both coasts (the West coast - Arabian Sea; and the East coast - Bay of Bengal) with greater frequency in the Bay of Bengal. The Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) reported that the Indian Ocean is experiencing the world's fastest rate of ocean surface warming. This ocean warming facilitates the genesis and maintenance of severe cyclonic storms.

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To ensure the viability of developmental projects and to extend their reach to include every citizen, it is essential to mainstream the management of cyclone disasters into developmental planning and to adopt an inclusive approach to risk mitigation. NIDM has identified the need for implementation support and enhancement of the capacity of institutions and individuals dealing with the Management of Cyclone Disasters. This module on the Management of Cyclone Disasters enables facilitators to adequately equip themselves to conduct training programs more effectively.

I compliment Prof. Surya Parkash, Head GMR Division, NIDM; Dr Raju Thapa, Former Junior Consultant; Dr Harjeet Kaur, Former Junior Consultant; Mr Hari Hara Kumar Devada, Former Young Professional, NIDM and other team members for their meticulous work and immense personal contribution in bringing out this publication. I also express my gratitude for the sincere and professional inputs from the external reviewers in assisting the NIDM in upkeeping the quality of this training module.

(Rajendra Ratnoo)

Preface

As one of the greatest challenges evidenced from the recent global COVID-19 response is multisectoral, multi-layered, multi-agency coordination, information sharing and partnership. As there are multiple stakeholders involved in the management of a cyclone disaster, the implementing agencies should provide stakeholders with timely, relevant, understandable, and accessible information, and consult with them in a culturally appropriate manner, which ensures transparency leading to an increase in partners' ability to work effectively. This training module in cyclone management will strengthen communications between multi-sectoral, multi-layered, multi-agency stakeholders facilitating decision-making and taking forward cyclone risk management in India.

Fostering and strengthening the knowledge, abilities, processes, and resources that enable communities and organisations to endure, adapt, and prosper in a world that is undergoing rapid change is the crucial objective of capacity-building initiatives in disaster management. An essential ingredient in disaster management capacity-building is the transformation that is generated and sustained over time from within; transformation of this kind goes beyond performing tasks to changing mindsets and attitudes. NIDM has served as the centre of capacity-building in disaster management in the county being the nodal agency. These capacity building would save lives and livelihoods, minimize damage, allow people, communities, countries, and economies to be prepared if a climate disaster threatens, and recover much faster from a hit.

Timely, accurate and reliable forecast and early warning by India Meteorological Department's (IMD) has led to safety and survival of human lives in cyclone prone areas. Advances in meteorology, weather forecasting and satellite imagery, as well as stronger risk governance, mean that disasters that would have cost thousands of lives in the past no longer exact as high a toll.

I express my gratitude for the sincere and professional inputs from the external reviewers in assisting the NIDM in the formulation of this training module.

I would like to express my sincere gratitude to Mr. S. K. Tiwari, NIDM; my team mates and co-authors for their contribution in developing this training module on cyclone management and I am sure this will go a long way in meeting the needs of multiple stakeholders who are supporting cyclone management in India.

(Surya Parkash)

Acknowledgement

I would like to acknowledge and give my warmest thanks to Shri Rajendra Ratnoo, IAS, Executive Director, NIDM for providing support and cooperation to successfully complete this document.

I owe an enormous debt of gratitude to our reviewers from NDMA and OSDMA who gave detailed and constructive comments on this training module. They gave freely of their time, wisdom, experience and expertise to bring the best out of this training module and pushed us to clarify concepts, explore facets of insight work, and explain the rationales for specific recommendations.

Sincere thanks to co-authors Dr Raju Thapa, Dr. Harjeet Kaur and Mr Hari Hara Kumar Devada who made every effort to collect, compile, analyse and assess all available information on management of cyclone disaster and helped in the preparation and finalization of this document.

My special thanks are due to the GMRD team members Mr. Ajit Batham, Mr Shubham Badola and NIDM publication team without which it would not have been possible in the preparation of this document completed.

I want to thank my wife, Reeta, for tolerating my incessant disappearances from my home for this work. Last but not the least, I would like to thank my daughter, Rasika for inspiring me every day to grow and be stronger, better and more fulfilled than I could have ever imagined.

Finally, I am grateful to the Almighty without whose grace and kindness, I would not have been capable to carry this task successfully.

(Surya Parkash)

Module at a Glance

Name: Training module on Management of Cyclone Disasters

Developed by: National Institute of Disaster Management (NIDM), New Delhi

Technical Support:

Technical Support: National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), National Informatics Centre (NIC), Vigyan Prasar, State Departments of Information and Broadcasting, Community Radios, India Meteorological Department (IMD), National Remote Sensing Centre (NRSC), Central Water Commissions (CWC), Geological Survey of India (GSI), Indian National Centre for Ocean Information Services (INCOIS), Indian Institute of Tropical Meteorology, Pune, Public Health professional etc.

Total Number of sub-modules: 07

Target Audience: SDMAs, DDMAs, Vigyan Prasar, State Departments of Information and Broadcasting, India Meteorological Department (IMD), Academicians, Researchers and Professionals working on disaster management, Disaster Management Centres at State ATIs & SIRDs, NGOs, CBOs, SHGs, Social Volunteers, Public Representatives, NDRF, SDRF, QRTs, RRFs, Paramilitary and Military Establishments, Administration, Local Bodies like Municipality and Panchayats, NSS, NYKS, NCC, Scouts and Guides, Home Guards, Civil Defence and Fire Fighters, Field Agencies like Border Roads, PWD, NHAI, PGCL, NHPC, THDC, NTPC, Stakeholders in Insurance, Finance, Planning, Policy, Development and Legal Sectors

Training programme on the basis of this module requires:

Training Days – 5 days

Training Hours – 38-40 Hours

Trainers required: Minimum 2

Training Materials: As mentioned inside

Total Pages: Approx 144 excluding annexure

Training Hall with sufficient number of movable chairs and tables

Module prepared by:

Dr. Surya Parkash, Professor and Head, Geo-meteorological Risk Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Government of India;

Shri Rajendra Ratnoo, IAS, Executive Director, National Institute of Disaster Management, Ministry of Home Affairs, Government of India.

Dr. Raju Thapa, Former Junior Consultant, Geo-meteorological Risk Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Government of India.

Dr. Harjeet Kaur, Former Junior Consultant, Coastal Disaster Risk Reduction & Resilience (CDRR&R) - Centre, Geo-meteorological Risk Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Government of India.

Mr Hari Hara Kumar Devada, Former Young Professional, Coastal Disaster Risk Reduction & Resilience (CDRR&R)-Centre, Geo-meteorological Risk Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Government of India.

Who Shall Use This Module

This module shall be used by a trainer involved in conducting courses on Management of Cyclone Disasters. The following individuals/organizations can be the potential users of this module:

- SDMA, DDMAs, and other disaster management professional.
- India Meteorological Department (IMD) etc.

- Academicians, Researchers and Professionals working on disaster management.
- Disaster Management Centres at State ATIs & SIRDs.
- NGOs, CBOs, SHGs, Social Volunteers, Public Representatives etc.
- NDRF, SDRF, QRTs, RRFs, Paramilitary and Military Establishments.
- Administration, Local Bodies like Municipality and Panchayats.
- NSS, NYKS, NCC, Scouts and Guides, Home Guards, Civil Defence and Fire Fighters.
- Field Agencies like Border Roads, PWD, NHAI, PGCL, NHPC, THDC, NTPC, Irrigation and Flood Control etc.

How to Use this Module

The training design brief will provide users with the objectives of the course, target audience, structure, training methodologies and resource materials etc.

The module will guide on how to carry out the evaluation and impact assessment of the training course with a set of questionnaires to be used and other necessary instructions. The actual training sessions will start with the sub-modules provided in the contents.

Trainer's Guide

The trainer/facilitator/course director may find the following tips useful for the smooth conduct of the training.

General

- During the inauguration/introduction session, the trainees should be asked to switch off or keep their mobiles/cell phones in silent mode during sessions and advised to attend only the urgent calls that too by going out of the training hall.
- Participants list with names, addresses, contact numbers, emails, etc. should be circulated for verification from the trainees and for necessary corrections.

- Entire training materials and equipment should be kept ready and checked before the training.
- Clear information about lunch hours and tea breaks should be given to trainees to avert any kind of delays. They should be informed exact time for the start of sessions and the following day's plans.
- Every possible care should be taken regarding logistic arrangements for the trainees to make them feel comfortable during the entire course of training.

Training Specific

The following points should be taken care of:

- Except the first day, each day shall start with a recapitulation session of about 15 minutes. At the end of each day, summary of the day's proceedings shall be shared with the participants for 10 minutes.
- Group composition shall change for every activity/exercise through different methods.

Contents

Abbreviations/Acronyms Used

ACWC	Area Cyclone Warning Centre
ADRR	Aviation Disaster Risk Reduction
AI	Artificial Intelligence
AIR	All India Radio
ARG	Automatic Rain Gauge
AWS	Automatic Weather Station
BMPTC	Building Materials and Technology Promotion Council
BoB	Bay of Bengal
BSS	Broadcast Satellite Services
CAP	Common Alerting Protocol
CAPE	Convective Available Potential Energy
CNES	Centre National d'Etudes Spatiales
CoR	Commissioner of Relief
CRMI	Cyclone Risk Mitigation Infrastructure
CRC	Cyclone Review Committee
CRZ	Coastal Regulation Zones
CWC	Cyclone Warning Centre
CWD	Cyclone Warning Division
CWDS	Cyclone Warning Dissemination System
DDMA	District Disaster Management Authority
DGM	Director General of Meteorology
DM	Disaster Management
DPP	Disaster Preparedness and Prevention
DP	Data Processing
DR	Data Reception

DRM	Disaster Risk Management
DWR	Doppler Weather Radar
ESMF	Environmental and Social Management Framework
GTO	Geosynchronous Transfer Orbit
GTS	Global Telecommunication System
GUAN	GCOS Upper-Air Network
HFA	Hyogo Framework for Action
HoDs	Head of Departments
HTL	High Tide Line
ICAO	International Civil Aviation Organisation
IDRN	India Disaster Resource Network
IHIP	Integrated Health Information Platform
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
IoT	Internet of Things
ISRO	Indian Space Research Organization
ITCZ	Intertropical Convergence Zone
LTL	Low Tide Line
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MoEFCC	Ministry of Environment, Forest and Climate Change
MoU	Memorandum of Understanding
MSW	Maximum Sustained Wind
NCDs	Non-Communicable Diseases
NCDC	National Centre for Disease Control
NCRMP	National Cyclone Risk Mitigation Project
NDBP	National Data Buoy Programme
NDMA	National Disaster Management Authority
NDMF	National Disaster Mitigation Fund

NDRF	National Disaster Response Force
NGOs	Non-Governmental Organisations
NIDM	National Institute of Disaster Management
NIO	North Indian Ocean
NWP	Numerical Weather Predictions
OCM	Ocean Colour Monitor
PBO	Pilot Balloon Observatories
PMP	Probable Maximum Precipitation
PMSS	Probable Maximum Storm Surge
ROSA	Radio Occultation Sounder for Atmosphere
RSMC	Regional Specialised Meteorological Centre
SDC	Swiss Agency for Development and Cooperation
SDMA	State Disaster Management Authority
SDMF	State Disaster Mitigation Fund
SDRN	State Disaster Resource Network
SOP	Standard Operating Procedure
SSO	Sun Synchronous Orbit
TCAC	Tropical Cyclone Advisory Centre
TCC	Tropical Cyclone Committee
TCs	Tropical Cyclones
UNCRD	United Nations Centre for Regional Development
TUTT	Tropical Upper Tropospheric Trough
UNESCAP	United Nations Economic and Social Commission for Asia-Pacific
UNISDR	United Nations International Strategy for Disaster Reduction
UTC	Universal Time Coordinated
VHRR	Very High Resolution Radiometer
WMO	World Meteorological Organisation

Context

Aim of the course

To provide knowledge and skills related to the management of cyclone disasters to a multi-stakeholder target group which is expected to play a role in reducing natural disaster incidences and impacts through various kinds of activities involving social, technical, legal, financial, environmental, administrative, and other such issues, aspects, and dimensions at different levels/scales.

Target Groups

The target group for this training program would be senior and middle level officers / functionaries from the Central / State / Local Government departments including Central Water Commissions (CWC), Vigyan Prasar, Indian National Centre for Ocean Information Services (INCOIS), Indira Gandhi National Open University (IGNOU), India Meteorological Department (IMD), Geological Survey of India (GSI), State Disaster Management Authority (SDMA), National Remote Sensing Centre (NRSC), Local Authorities / Bodies (PRIs and ULBs), Social Welfare, State Department of Land Revenue and Disaster Management, Administrative Training Institute (ATIs), Academic and research institutes, NGOs, CBOs and VOs etc.

The participants are expected to have varied responsibilities, academic backgrounds & experience. They are also required to be equipped with minimal level of knowledge, skills, information and experience related to the management of cyclone disasters for taking up their tasks effectively in their organizations. They are expected to deal with cyclone management during planning and implementation of developmental activities. The programme is intended to provide comprehensive knowledge and skills in the field of cyclone risk management to these participants.

Assumptions about Trainees

It is assumed that the age of trainees varies in the relevant sectors. The academic qualifications will also be variable in discipline and level of degrees. They may or may not have experience/exposure to disasters prior to the training.

Why This Training?

Lack of adequate knowledge, skills, and information about the Management of the Cyclone disaster have aggravated the losses of lives and properties and prolonged the recovery process. Informed, skilled and trained human resources can play a significant role in understanding and implementing information and communication in disaster management. The training aims to fill this gap in a proactive mode by imparting skills, knowledge and information related to National Disaster Management Information and communication systems.

Training Needs

Interaction with the various concerned organizations leads to the conclusion that disasters incidences and impacts are rising due to lack of adequate trained human resources with these organizations besides the fact that affected communities are also unaware, uninformed, and unprepared. Different stakeholders as well as the affected communities need to be made aware, informed, and prepared to assess the potential/impending disaster risks, minimize the risks, and prepared themselves against the remnant risk.

Relevance of Objectives to Training Needs

The objectives of the training programme are formulated to cater to the training needs of different stakeholders for carrying out their tasks more effectively and efficiently in order to reduce disaster risks and manage their impacts on life, economy and environment with a better understanding of Communications for Disaster Management.

Time Constraint

There will be no time constraints for holding training course. Hence, relevant participants shall be available throughout the year.

Trainers

Senior level officials from Central/State/Local Government departments including National Disaster Management Authority (NDMA), Central Water Commissions (CWC), Vigyan Prasar, Indian National Centre for Ocean Information Services (INCOIS), India Meteorological Department (IMD), National Remote Sensing Centre (NRSC), Geological Survey of India (GSI), National Institute of Disaster Management (NIDM), National Disaster Response Force (NDRF), Academician etc.

Logistics

Boarding and lodging arrangements for 20-25 participants.

Number of Trainees

20 to 40 participants from various departments/agencies.

Venue(s) for Training

NIDM, State ATIs and other relevant training centers.

Language

Language of instruction is English. All the Presentations/Demonstrations/ Drills/Exercises have been prepared in English but can be translated into local languages for understanding by layman. Interactions can be also in Hindi or any other vernacular languages depending upon the requirement of the State.

Time Frame

Training shall be held for 5 days.

Training Methods

Lectures/Interactive Discussions/Power Point Presentations/Slide Shows/ Brainstorming Discussions/Panel Discussions/Experience Sharing/Participatory Learning/Needs Assessment/Case Studies/Guided Group Exercises (Table Top and Simulation)/Hands on Exercises/Practicals/Skill Transfer/Mock Drills/ Demonstration and Exposure Visit/Guided Field Work.

Media and Equipments

Computers, LCD Projector, Screen, Laser pointer, Overhead Projectors, White board, Flip Charts and Stand, Markers, Mike and Speakers (PA system), Camera, GPS.

Performance Aids

Flip Charts, Lecture Notes/Hand-Outs of Presentations, Questionnaires, Check List, Formats for Data Collection/Templates/Exercises for Case Studies.

Training Materials

Note Pad, Pen, Folder/Bag, CD, Sketch Pens, and Flip Charts

Measures for Transfer of Learning

Each trainee shall submit an action plan to implement and impart training skills at his/her organization. Trainees will be asked to submit a short term project within one month to demonstrate their level of learning from the course and their efficiency in using the skills.

Assessment, Feedback and Validation Measures

During the course, questionnaires will be distributed to assess the level of learning of the participants. Daily session-wise evaluation will be done through recapitulation of learning of the previous day. Trainer/Facilitator will also evaluate transfer of skills during role plays, exercises and mock drills by the participants. At the end of course, a feedback evaluation form will be given to the participants to know the perception about the course. External validation shall be done through short term projects and feedback from the head of the sponsoring agency.

Benefits

1. Pool of trained human resources who can cater to the needs for assessing disasters risks and help in managing them or reducing their risks at various levels, viz., local, district, state and national levels.

2. Reliable and credible system for disasters risk management would become available.
3. Networking and co-ordination among various stakeholders will be strong.

Cost of Training (Per Course)

Includes TA/DA for Resource Persons, Training Kit, Stationery Cost, Expenditure on Field Visit, Boarding and Lodging Charges for the Participants, Transportation Charges, Photography, Xeroxing/Binding of Reading Material/Hand Notes, Hospitality Charges for Resource Persons, Communication Charges (Mobile/ Telephone/Postage), Tutor Expenses, Miscellaneous/Contingent Charges and Administrative/Overhead Charges.

Approximate Budget

Rs. 2,000/- per participant per day

Day 1 - Learning Event

Topic 1-1: Registration

Learning Objectives:

- Personal & Organizational Information about trainees
- Expectations from the Course
- Experience of Participant

Contents

- Filling of Registration Form
- Compilation of registration record
- Profile of trainees/organizations

Time and Duration: 09:30-10:00 hrs (30 min.)

Method: Performa for Registration

Facilitator: Training Assistant

Topic 1-2: Introduction and Inauguration

Learning Objectives:

- Mutual Introduction of participants
- Experience Sharing
- Course Introduction
- Significance of Programme & Paradigm Shift

Contents

- Welcome to Participants
- Experience Sharing and Expectations
- Entry Behaviour
- Ground Rules
- Course Introduction
- Inaugural Address

Time and Duration: 10:00-11:30 hrs (90 min.)

Method: Mutual Interaction

Resource Person(s): Course Director and Guest Speaker

Topic 1-3: Introduction to Disaster Risk Management

Learning Objective:

- Basic of disaster management,
- Paradigm shift in disaster management at global and national level,
- Initiatives on natural disaster risk reduction programme,
- Natural hazard profile in India

At the end of this training unit, the participants will be able to:

- Understand the basics of Disaster Management.
- Disaster Management prevailing global scenario as well as the scenario in India.

- Paradigm shift in disaster management in India.
- Disaster Management Act, 2005.
- Institutional framework in DM Act 2005.
- Natural hazard profile in India.

Time and Duration: 11:45-13:00 hrs (75 min.)

Method: Lecture, Presentation and Discussions with field examples

Topic 1-4: Introduction to Cyclone and Cyclone Monitoring and Warning System

Learning Objective

- Basics to Cyclone
- Hazard due to Cyclone
- Cyclone scenario in India

At the end of this training session, the participants will be able to develop understanding of:

- Cyclone formation
- Hazard due to Cyclone
- Storm Intensity, Expected Damage and Suggested Actions
- Genesis of Cyclone
- Vital Parameters of Tropical Cyclone
- Cyclone scenario in India

Time and Duration: 14:00 -15:30 hrs (90 min.)

Method: Lecture, Presentation and Discussions with field examples

Topic 1-5: Implementation of Cyclone Warning System: A Case Study

Learning objective

- To discuss Cyclone case studies related to India highlighting various phases of Cyclone management system

Method: Lecture, Presentation and Discussions with a case study

Time and Duration: 15:45-17:00 hrs (75 min.)

Summary of the Day-1: Recalling Day-1's deliberations

Time and Duration: 17:00-17:30 hrs (30 min.)

Method: Mutual Interaction

End of Day-1

Day 2 - Learning Event

Topic 2-1: Recapitulation of Day-1

Learning Objectives:

Recalling the Learning from the Previous Day

Contents:

- Recapitulation by Participants
- Reference to the Reading Material

Method: Oral/Flip Chart

Time and Duration: 09:30-10:00 hrs (30 min.)

Topic 2-2: Public Health Emergencies during cyclone

Learning Objectives:

- Cyclone compounded disasters and public health emergencies
- Need for a Multi-hazard approach
- Building Resilience of the Most Vulnerable
- Towards building the resilient recovery
- Community Assessment for Public Health Emergency Response (CASPER)

At the end of this training session, the participants will be able to:

- Public health emergencies during cyclone disasters
- Protecting the most vulnerable from the cascading risks
- Early warning for early actions to protect
- Building Resilience of the Most Vulnerable
- Capitalizing on regional cooperation
- Building the resilient recovery
- Community Assessment for Public Health Emergency Response (CASPER)
- Case Study

Method: Lecture, Presentation and Discussions with a case study

Time and Duration: 10:00-11:30 hrs (90 min.)

Topic 2-3: Cyclone Risk Management and Capacity Development

Learning Objectives:

- Vulnerability Analysis and Risk Assessment
- Cyclone Disaster Management Information System
- Capacity Development, Community Capacity Building
- National Cyclone Disaster Management Institute (NCDMI)

At the end of this training session, the participants will be able to:

Learning Objectives:

- Basics of hazard, vulnerability, risk, capacity
- Preparedness measures for cyclones
- Awareness Programmes
- Community Awareness
- Community Based Disaster Management (CBDM)

Method: Lecture, Presentation and Discussions with a case study

Time and Duration: 11:45-13:00 hrs (75 min.)

Topic 2-4: Mitigation Measures

Learning Objectives:

- Structural Mitigation Measures
- Non-structural Mitigation Measures

At the end of this training session, the participants will be able to:

- Overview
- Buildings: Cyclone Shelters

- Road Links, Culverts and Bridges
- Canals, Drains, Surface Water Tanks
- Saline Embankments
- Communication Towers and Power Transmission Networks

Method: Lecture, Presentation and Discussions with a case study

Time and Duration: 14:00-15:30 hrs (75 min.)

Topic 2-5: Mitigation Measures

Learning Objectives:

- National Cyclone Risk Mitigation Project

At the end of this training session, the participants will be able to:

- Mission Statement
- Key Objectives
- NCRMP Phase-I
- NCRMP Phase-II
- Benefit Monitoring & Evaluation of NCRMP

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 15:45-17:00 hrs (75 min.)

Summary of the Day-2

Recalling Day-2's deliberations

Mutual Interaction

Time and Duration: 17:00-17:30 hrs (30 min.)

End of Day-2

Day 3 - Learning Event

Topic 3-1: Recapitulation of Day-2

Learning Objectives

Recalling the Learning of Previous Day

Contents:

- Recapitulation by Participants
- Reference to the Reading Material

Method: Oral/Flip Chart

Time and Duration: 09:30-10:00 hrs (30 min.)

Topic 3-2: Role and Responsibilities

Learning Objectives:

- Role of Ministry
- Implementation and Coordination at the National Level
- Institutional Mechanism and Coordination at State and District Levels
- Implementation of the Guidelines: Preparation of Cyclone DM Plans

At the end of this training session, the participants will be able to:

- Coordination at National, State and District Levels
- Implementing the Guidelines
- Implementation and Coordination at the National Level
- Institutional Mechanism and Coordination at State and District Levels

Method: Lecture, Presentation, and Brainstorming Discussions

Time and Duration: 10:00-11:30 hrs (90 min.)

Topic 3-3: Cyclone Response

Learning Objectives:

- Disaster Response Mechanism
- Disaster Response Platform
- Linking Risk Knowledge with Response Planning
- Effective Disaster Response Capability
- Other Supportive Efforts
- Development of Evacuation Plan with Schedule of Actions

At the end of this training session, the participants will be able to:

- Institutional Arrangements
- Emergency Operations Centre
- Plan maintenance
- Mock Drills

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 11:45-13:00 hrs (75 min.)

Topic 3-4: Emergency Operations Centres: Connectivity, Database & Applications Development

Learning Objectives:

- Introduction
- Flow of Information for EOCs at Different Levels
- Vertical & Horizontal Connectivity of NDCN
- Detailed Design of the Core Network
- Applications and Database Required at NEOC, EOCs (at state and district level)
- Generic Requirements at EOCs
- Facilities at NEOC and SEOCs

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 14:00-15:30 hrs (95 min.)

Topic 3-5: India Disaster Resource Network (IDRN)

Learning Objectives:

- IDRN Overview
- Supply Chain Management during disasters
- Need for IDRN
- IDRN Architecture

At the end of this training session, the participants will be able to:

- IDRN Maintenance & Monitoring
- Data Collection Process
- State-level coordination for building inventory database
- Role of NIDM in IDRN

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 15:45 – 17:00 hrs (75 min.)

Summary of the Day-3

Recalling Day-3 deliberations

Mutual Interaction

Time and Duration: 17:00-17:30 hrs (30 min.)

End of Day-3

Day 4 - Learning Event

Topic 4-1: Recapitulation of Day-3

Enabling Objectives:

Recalling the learning from the previous day

Contents:

- Recapitulation by Participants
- Reference to the Reading Material & Discussions

Method: Oral/Flip Chart

Time and Duration: 09:30-10:00 hrs (30 min.)

Topic 4-2: Field Exposure

Enabling Objectives:

- Understanding disaster communication

Method:

Exposure Visit/Guided Field Work/Simulation Exercise/Mock drill

Time and Duration: 10:00-17:30 hrs (450 min.)

End of Day-4

Day 5 - Learning Event

Topic 5-1: Recapitulation of Day-4

Enabling Objectives:

Recalling the Learning of the Previous Day

Contents:

- Recapitulation by Participants
- Reference to the Reading Material, Field Discussions and Presentations

Method: Oral / Flip Chart

Time and Duration: 9:30-10:00 hrs (30 min.)

Topic 5-2: Rapid Response Teams in the context of public health Emergencies during Disasters

Enabling Objectives:

- Emergency response capacity building during active disaster response
- Risk Assessment and Monitoring
- Infection Prevention and Control in the context of disaster response
- How to engage communities and communicate risk in the context of disaster response

At the end of this training session, the participants will be able to:

- Constitute an RRT for emergency response during cyclone disaster
- Collect and manage the data for decision-making in the context of cyclone disaster
- Prevent and control infections (early identification and source control, environmental cleaning and disinfection, home-based care, safe management of a dead body, etc.) related to cyclone disaster; and
- Engage communities and communicate risk in the context of COVID-19.

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 10:00-11:30 hrs (90 min.)

Topic 5-3: Technology and Emerging Trends

Training Objectives:

- Community-based Early warning system
- Community Radio, Amateur Radio
- Social Media in disaster Management
- Common Alert Protocol (CAP)

At the end of this training session, the participants will be able to:

- Need for enhancing Community-based Early warning system
- Promoting engagement of Community Radio and Amateur Radio in disaster response
- Utilising the opportunity provided by Social Media in Disaster Management
- Understanding the concept and function of Common Alert Protocol (CAP)

Method: Lecture, Presentation and Discussions with a Case Study

Time and Duration: 11:45-13:00 hrs (75 min.)

Topic 5-4: Presentation and Feedback of Field Visit and Simulation Exercise

Training Objectives:

- Comments on Technical/Managerial Content
- Observations on Attitudinal Aspects and Team Spirit

Method: Flip Charts, Power Point Group Presentation

Time and Duration: 14:00 -15:30 hrs

Topic 5-5: Quiz with respect to course

Training Objectives:

Knowledge Check

Method: Slide Show, Question-Answers

Time and Duration: 15:45-16:30 hrs (45 min.)

Topic 5-6: Evaluation, feedback, certification, and valediction

Contents:

Feedback from Participant

Post-training Assignment

Method: Follow-up Strategy

Time and Duration: 16:30-17:30 hrs (45 min.)

End of the Course

Sub-Module 1: Introduction to Disaster Risk Management

1.1 Introduction

A Disaster is an event or series of events, which gives rise to casualties and damage or loss of properties, infrastructure, environment, essential services, or means of livelihood on such a scale that is beyond the normal capacity of the affected community to cope with. Disaster is also sometimes described as a "catastrophic situation in which the normal pattern of life or ecosystem has been disrupted and extraordinary emergency interventions are required to save and preserve lives and or the environment" (https://nidm.gov.in/PDF/Disaster_about.pdf)

Owing to the peculiar geo-climatic conditions that prevail in the Indian landmass and its geophysical nature, India has been exposed to a slew of catastrophic natural disasters such as landslides, cyclones, tsunamis, floods, earthquakes, droughts on a regular basis, resulting in mass casualties, property, and environmental damage, and is thus regarded as one of the most disaster-prone countries. Due to expanding population, unplanned urbanisation, structural development in high-risk zones, environmental degradation, climate change, and other factors, susceptibility to natural and man-made catastrophes has increased during the previous four to five decades (NDMA, 2012).

1.2 Paradigm shift in disaster management

Natural disaster-related economic losses in the recent decade were the highest on record, totaling $3 trillion, more than a trillion more than the preceding decade. Floods, tsunamis, earthquakes, and tropical cyclones were among the disasters that struck the Asia-Pacific area between 2010 and 2019, accounting for 44 percent of all disasters. The substantial spike in economic loss was attributed to more extreme weather events, larger populations in disaster areas, and greater supply chain disruption in a globalised economy (Reuters, 2021).

In the pre-disaster scenario of the disaster management continuum, holistic disaster management calls for prioritising disaster prevention, mitigation, and preparedness activities, while bolstering initiatives for a better and more accurate responding via highly trained personnel, highly developed tools, and improved building during the reconstruction and rehabilitation period. As a result, the holistic DM cycle has been concentrated on four overlapping phases in the context of natural disasters: mitigation, readiness, response, and recovery (NDMA, 2012). Disaster management continuum is shown in Fig. 1.1

Fig. 1.1 Disaster management continuum

Given the massive effects of natural disasters, which have led to large amount of fatalities and significant property damage, infrastructural facilities, and the environment globally, mainly in developing nations, the United Nations General Assembly decided to declare the 1990s as the International Decade for Natural Disaster Reduction (IDNDR) through International Cooperation for Saving Lives on the 11th of December, 1987.

Subsequently, on December 22, 1989, the United Nations General Assembly declared the International Decade for Natural Disaster Reduction, which would begin on January 1, 1990, and established the required "International Framework of Action" for this Decade. The goal of the Worldwide Decade for Natural Disaster Reduction was to decrease the loss of life, property damage, and disruption of social and economic environments caused by natural catastrophes by coordinated international effort, particularly in poor nations. The international conference on Natural Disaster Reduction in the city of Yokohama, Japan (23rd – 27th May, 1994) confirmed many inter-alia in order to review the status of disaster reduction midway through the decade and to work out the strategy and plan of action for a safer world.

Considering the fact the nation's hazard profile and its impact on the national economy at periodic intervals in general, and the impact of the last few major disasters in specific, such as Uttarakhand floods 2013, Kashmir earthquake 2005, Indian Ocean earthquake and tsunami 2004,

Bhuj Earthquake 2001, Orissa Super cyclone 1999, leading to the loss of approximately Rs 34,400 crores in property and 40,200 lives, (NDMA, 2012). India decided to change from a reactive approach to a holistic approach to disaster management by incorporating technology and innovation through all facets of the disaster management continuum with the introduction of Disaster Management Act 2005 on December 23, 2005, which was unanimously passed by the Parliament. In general, this strategy asks for the development and implementation of effective technological and scientific infrastructures, as well as the construction of dependable and dedicated disaster communication systems based on modern technology (NDMA, 2012).

In India, the Disaster Management Act 2005 explicitly defines the organisational structure and functional duties for disaster management. The National Disaster Management Authority (NDMA), an apex organisation led by the Prime Minister as Chairperson, was established under the Disaster Management Act of 2005. The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management. A diagrammatical representation of the National Disaster Management Structure is given at Fig. 1.2.

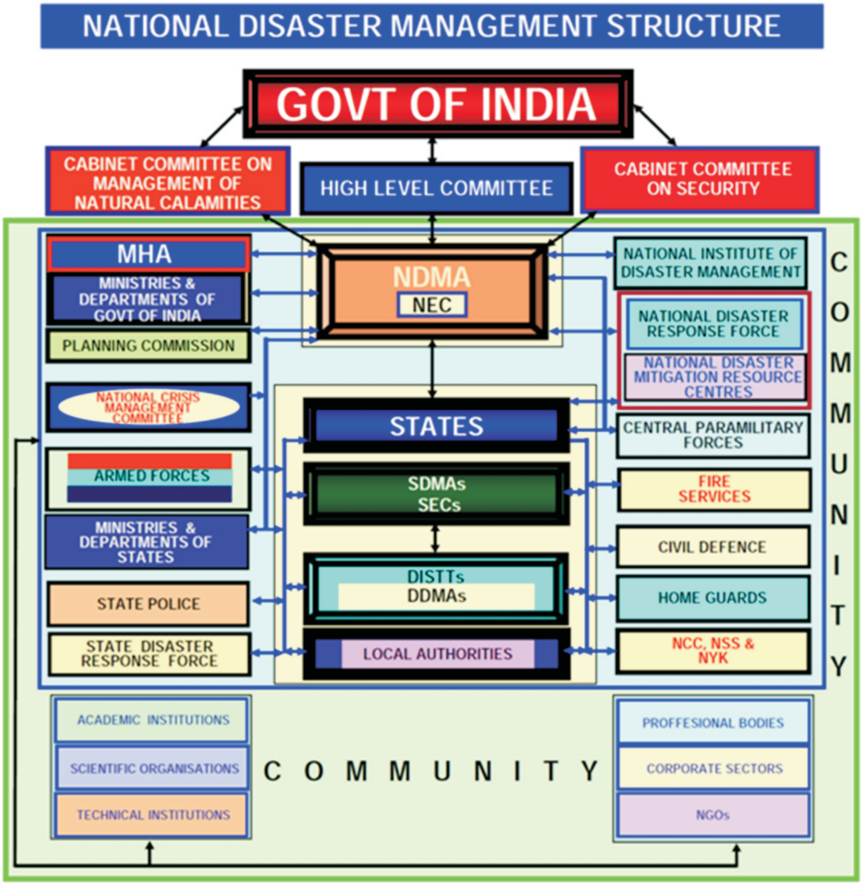

Fig. 1.2 This diagram reflects interactive linkages for synergised management of disasters and not a hierarchical structure.

1.3 Hazard profile of India

Well almost 58.6% of the Indian total area is vulnerable to earthquakes of various magnitudes; about 12% of the Indian land mass, covering over 50 million hectares, is vulnerable to floods and subsequent land erosion; about 8% of the total area is vulnerable to cyclones; and 68 percent of the area is vulnerable to drought. Approximately 5700 km of India's lengthy coastline, which stretches for 7516 km, is vulnerable to cyclones and tsunamis (NDMA, 2012). With expanding population, unplanned urbanisation, development in high-risk zones, environmental degradation, climate change, and other factors, susceptibility to natural and man-made disasters has increased during the previous four to five decades.

1.3.1 Hazard Risk Maps for India

Vulnerability Atlas of India, Third Edition 2019, Building Materials and Technology Promotion Council (BMTPC)

Fig. 1.3 Cyclone Occurrence map
(http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/Index.html)

Flood Hazard Map

http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/flood.html

Wind Hazard Map

http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/wind.html

Earthquake Hazard Map

http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/eq.html

Landslide Incidence Map

http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/landslide.html

Thunderstorm Incidence Map

http://www.bmtpc.org/DataFiles/CMS/file/VAI2019/th.html

Sub-Module 2: Introduction to Cyclone

2.1 Introduction

Cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure. The word "Cyclone" is derived from the Greek word 'Cyclos" meaning the coil of a snake. Tropical cyclones are also referred to as 'Hurricanes' over Atlantic Ocean, 'Typhoons' over Pacific Ocean, 'Willy-Willies' over Australian Seas and simply as 'Cyclones' over North Indian Ocean (NIO). The criteria followed by the India Meteorological Department (IMD) to classify the low pressure systems in the Bay of Bengal (BoB) and in the Arabian Sea as adopted by the World Meteorological Organisation (WMO) are given in Table 2.1.

Table 2.1 Criteria for classification of cyclonic disturbances over the North Indian Ocean

Sl. No.	Type of disturbance	Associated maximum sustained wind (MSW)
1.	Low Pressure Area	Not exceeding 17 knots (<31 kmph)
2.	Depression	17 to 27 knots (31-49 kmph)
3.	Deep Depression	28 to 33 knots (50-61 kmph)
4.	Cyclonic Storm	34 to 47 knots (62-88 kmph)
5.	Severe Cyclonic Storm	48 to 63 knots (89-117 kmph)
6.	Very Severe Cyclonic Storm	64 to 119 knots (118-221 kmph)
7.	Super Cyclonic Storm	120 knots and above ($\geq$222 kmph)

In a fully developed cyclonic storm, there are four major components of horizontal structure viz. eye, wall cloud region, rain/spiral bands and outer storm area (Fig. 2.1).

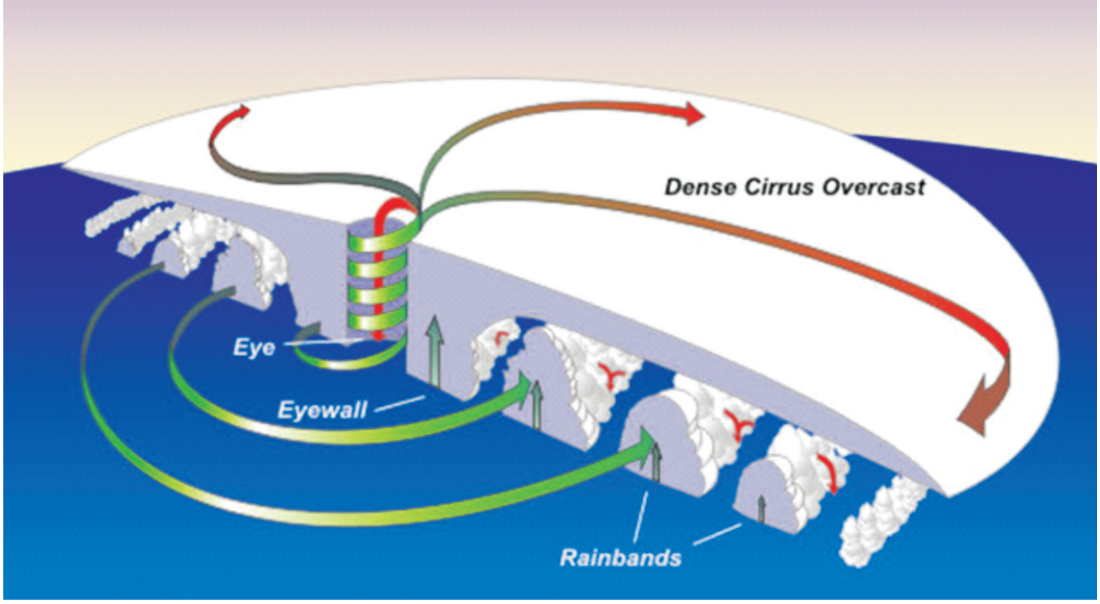

Fig. 2.1 Schematic diagram indicating major component of a cyclone
(Source: https://www.noaa.gov/jetstream/tropical/tropical-cyclone-introduction/tropical-cyclone-structure)

The vertical structure of a cyclonic storm can be divided into three layers viz. Inflow layer, middle layer and outflow layer. The average life span of a cyclonic storm over the North Indian Ocean (NIO) is about 4 to 5 days which can be divided into four stages namely formative stage, immature stage, mature stage and decaying stage (IMD, 2013). The formative stage covers the period from the genesis of a cyclonic circulation to the cyclonic storm stage through low pressure, depression and deep depression stages. In the immature stage, the central pressure of the system continues to fall till the lowest pressure is attained. The wind speed increases and usually at a distance of about 30-50 km from the centre resulting in a well developed eye wall. During the mature stage, no further fall of pressure and increase of wind speed occur. In the decaying stage, the tropical storms begin to lose its intensity when they move over to land, colder water or lie under an unfavorable large-scale flow aloft.

2.2 Hazard due to cyclone

Disturbed weather occurs generally in association with low pressure systems that are seen over different parts of the globe. Areas of high pressure are characterized by fair weather. The severity of weather increases with the increase in intensity of the low pressure. The cyclonic storms cause heavy rains, strong winds and also high seas and devastate coastal areas at the time of landfall, leading to loss of life and property. Types of damages associated with a tropical cyclone are also shown in Fig. 2.2.

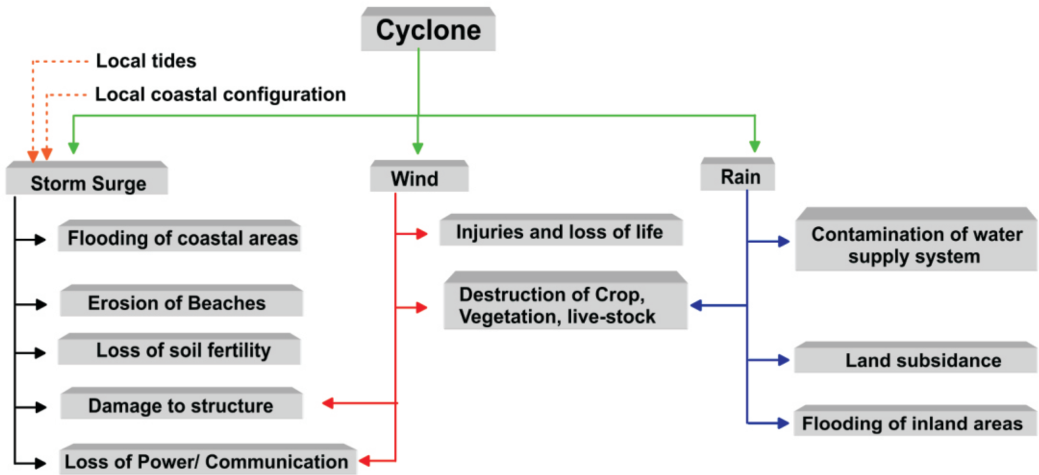

Fig. 2.2 Types of Potential Damages accompanying Tropical Cyclones

Table 2.2 Storm Intensity, Expected Damage and Suggested Actions

Sl . No.	Intensity	Damage expected	Action Suggested
1.	Deep Depression 50–61 kmph (28-33 knots)	Minor damage to loose and unsecured structures	Fishermen advised not to venture into the open seas.
2.	Cyclonic Storm 62–87 kmph (34-47 knots)	Damage to thatched huts. Breaking of tree branches causing minor damage to power and communication lines	Total suspension of fishing operations

Sl. No.	Intensity	Damage expected	Action Suggested
3.	Severe Cyclonic Storm 88-117 kmph (48-63 knots)	Extensive damage to thatched roofs and huts. Minor damage to power and communication lines due to uprooting of large avenue trees. Flooding of escape routes.	Total suspension of fishing operations. Coastal hutment dwellers to be moved to safer places. People in affected areas to remain indoors.
4.	Very Severe Cyclonic Storm 118-167 kmph (64-90 knots)	Extensive damage to kutcha houses. Partial disruption of power and communication line. Minor disruption of rail and road traffic. Potential threat from flying debris. Flooding of escape routes.	Total suspension of fishing operations. Mobilise evacuation from coastal areas. Judicious regulation of rail and road traffic. People in affected areas to remain indoors.
5.	Very Severe Cyclonic Storm 168-221 kmph (91-119 knots)	Extensive damage to kutcha houses. Some damage to old buildings. Large-scale disruption of power and communication lines. Disruption of rail and road traffic due to extensive flooding. Potential threat from flying debris	Total suspension of fishing operations. Extensive evacuation from coastal areas. Diversion or suspension of rail and road traffic. People in affected areas to remain indoors.
6.	Super Cyclone 222 kmph and more (120 knots and more)	Extensive structural damage to residential and industrial buildings. Total disruption of communication and power supply. Extensive damage to bridges causing large-scale disruption of rail and road traffic. Large-scale flooding and inundation of sea water. Air full of flying debris	Total suspension of fishing operations. Large-scale evacuation of coastal population. Total suspension of rail and road traffic in vulnerable areas. People in affected areas to remain indoors.

Source: IMD, 2013

2.2.1 Winds

The damages produced by winds are extensive and cover areas occasionally greater than the areas of heavy rains and storm surges which are in general localized in nature.

Fig. 2.3 Cyclone Fani hits Puri with wind speeds of 240-245 kmph
(Source: https://www.wionews.com/india-news/puri-hit-with-wind-speed-of-240-245-kmph-cyclone-fani-moving-towards-west-bengal-coast-imd-215613)

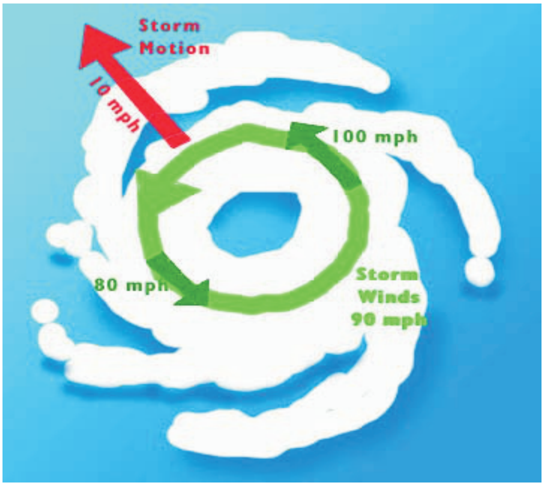

Fig. 2.4 Schematic diagram showing the variation of wind speed in tropical cyclone

In tropical cyclone occurring in northern hemisphere, the strongest winds are located in the front quadrant and eyewall of the tropical cyclone (Fig. 2.4).

2.2.2 Rainfall

Rainfall is generally very heavy and spread over a large area thus, leading to excessive amount of water often submerging large land masses. Rains (sometimes even more than 30 cm per 24 hrs) occur in association with cyclones. Unabated rains give rise to unprecedented floods. Rainwater on the top of storm surge may add to the fury of the storm and creates problems in post cyclone relief operations also.

Fig. 2.5 Flood caused by Cyclone Fani, 2019
(Source: India Today, accessed on 12/10/2022)

2.2.3 Storm Surge

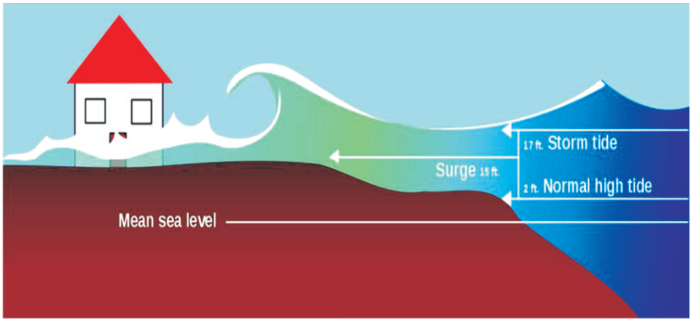

Fig. 2.6 Strom Surge
(Source: Energy Education, accessed on 12/10/2022)

Storm surge is the major cause of devastation from tropical storms. Though, the deaths and destruction are caused directly by the winds in a tropical cyclone as mentioned above, these winds also lead to massive piling of Sea water in the form of what is known as storm surge that lead to sudden inundation and flooding of coastal regions. The surge is generated due to interaction of air, sea and land. When the cyclone approaches near the coast, it provides additional force in the form of very high horizontal atmospheric pressure gradient which leads to strong surface winds.

2.2.4 Marine Impact

The wind speed, condition of sea and wave height associated with 'T' numbers of various categories of cyclonic disturbances, are given in Table 2.3. Condition of the sea becomes high to Phenomenal with wave height of 6 metre or more during cyclone period.

Table 2.3 Marine impact of cyclonic disturbances

Sl. No.	Intensity	Strength of wind (kmph/knots)	Satellite 'T' No.	Condition of Sea	Wave height (m)
1.	Depression	(i)(31- 40)/(17-21) (ii)(41- 49)/(22-27)	1.5	Moderate Rough	1.25-2.5 2.5-4.0
2.	Deep Depression	(50–61)/(28-33)	2.0	Very Rough	4.0-6.0
3.	Cyclonic Storm	(62–87)/(34-47)	2.5-3.0	High	6.0-9.0
4.	Severe Cyclonic Storm	(88-117)/(48-63)	3.5	Very High	9.0-14.0
5.	Very Severe Cyclonic Storm	(i)(118-167)/(64-90) (ii)(168-221)/(91-119)	4.0-4.5 5.0–6.0	Phenomenal Phenomenal	Over 14.0
6.	Super Cyclonic Storm	(222/120 and more)	6.5 and more	Phenomenal	Over 14.0

2.3 Genesis of cyclone

In the genesis of cyclone several influencing factors namely warm sea surface, Coriolis force, conditional instability, high humidity, high humidity and enhanced vorticity in troposphere and weak wind shear contribute to its formation.

2.3.1 Warm Sea Surface

The sea surface temperature must be at least 26.5°C (79.7°F) with a minimum of 50 metre depth of warm surface water which enable heat transfer and strong evaporation from the sea surface into the boundary layer (Still 2017) servings as fuels of tropical systems (Fig. 2.7).

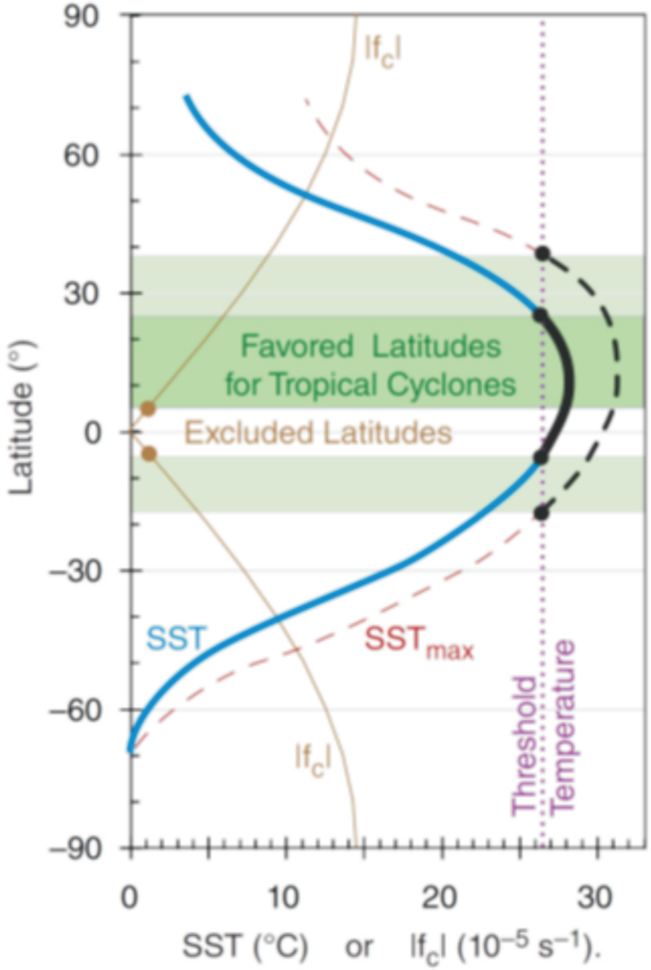

Fig. 2.7 Approximate zonal average sea-surface temperature SST (°C, thick solid blue line)

2.3.2 Coriolis Force

In the lower half of the troposphere, winds are forced around the eye due to coriolis force and the flowing of the wind is tangent around the eye rather than radially into it. The tropical cyclone can persist for many days as only a small portion of air convergences toward the eye. Tropical cyclones cannot exist in $\leq 5°$ latitude as the coriolis force acting in these regions are nearly zero (at equator coriolis force is exactly zero). The boundary-layer air would be sucked directly into the low pressure eye of the cyclone accumulating air molecules and increasing air pressure in the eye. Thus, the tropical cyclone would die of due to gradual reduction of low pressure.

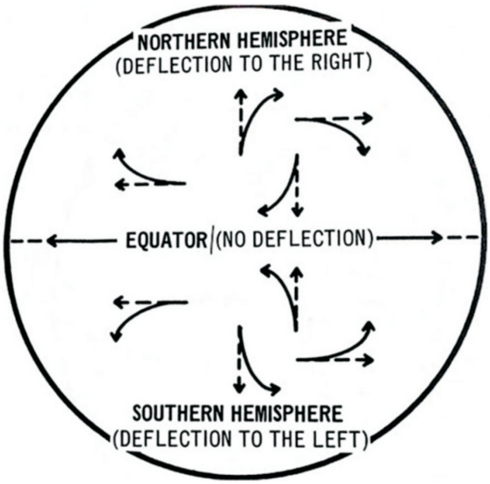

Fig. 2.8 Coriolis force acting on Northern and Southern hemisphere

2.3.3 Conditional Instability

Non-local conditional instability is prerequisite for cyclone formation. The boundary layer must be relatively warm compared to the mid-troposphere and warm humid boundary layer is superimposed by stable layer. Strong heat and moisture fluxes into the atmosphere released from the warm sea surface leads to the formation of the warm humid boundary layer and the trade-wind inversion forms the cap warm humid boundary layer. These atmospheric conditions in addition to the a cool mid troposphere cause large values of Convective Available Potential Energy (CAPE) implying sufficient nonlocal conditional instability for tropical cyclones.

2.3.4 High Humidity

For incipient thunderstorms to organize and grow into tropical cyclones, high humidity at roughly 5 km above sea level in a deep layer of atmosphere is essential. Presence of dry air in the vicinity of the storm restrict the development and intensification of a tropical cyclone as in dry air ascending motions is restricted as dry air is less buoyant than moist air. The latent heat release and the net condensation decreases as ascending air parcels are prevented from attending saturation due to the presence of dry air.

2.3.5 Synoptic-scale Vorticity

The development and intensification of a tropical cyclone from thunderstorms requires high relative vorticity in the bottom half of the troposphere and in their absences high relative vorticity causes thunderstorms that are form to act somewhat independently of each other.

2.3.6 Weak Wind Shear

The thunderstorm clusters formation (precursors to tropical cyclones) is enabled when the wind shear of the incipient storm is weak ($\Delta M < 10$ m/s between pressure levels 80 and 25 kPa). When wind shear is very strong, latent heating due to water-vapor condensation is spread over a broader area and the updrafts in the thunderstorms become tilted resulting in less-concentrated warming and a reduced ability to create a low-pressure center at sea level around which the development and intensification of a tropical cyclone from thunderstorms takes place.

2.3.7 Tropical Cyclone Triggers

A triggering mechanism is required to initiate the development and intensification of a tropical cyclone in addition to the fulfillment of all the above conditions. A triggering mechanism creates synoptic-scale horizontal convergence in the atmospheric boundary layer forcing upward motion out of the boundary-layer initiating incipient tropical cyclones. Some common triggering mechanisms are Intertropical Convergence Zone (ITCZ), Monsoon troughs, Tropical Upper Tropospheric Troughs, mid-latitude fronts that reach the tropics etc.

2.3.7.1 Intertropical Convergence Zone (ITCZ)

The Intertropical Convergence Zone (ITCZ) is the area where the southeast trade winds from the Southern Hemisphere converge with the northeast trade winds from the Northern Hemisphere. It shifts and changes its position seasonally and encircles Earth near the thermal equator. The ITCZ are also known as the calms or the doldrums because of its monotonous, windless weather. During the months of

August - September and February – March the ITCZ shifts between about 10°N in Northern Hemisphere and 10°S in southern Hemisphere respectively. During these periods, ITCZ has the maximum asymmetry in global heating and also have sufficient Coriolis force (since far enough from the equator) for the development and intensification of a tropical cyclone.

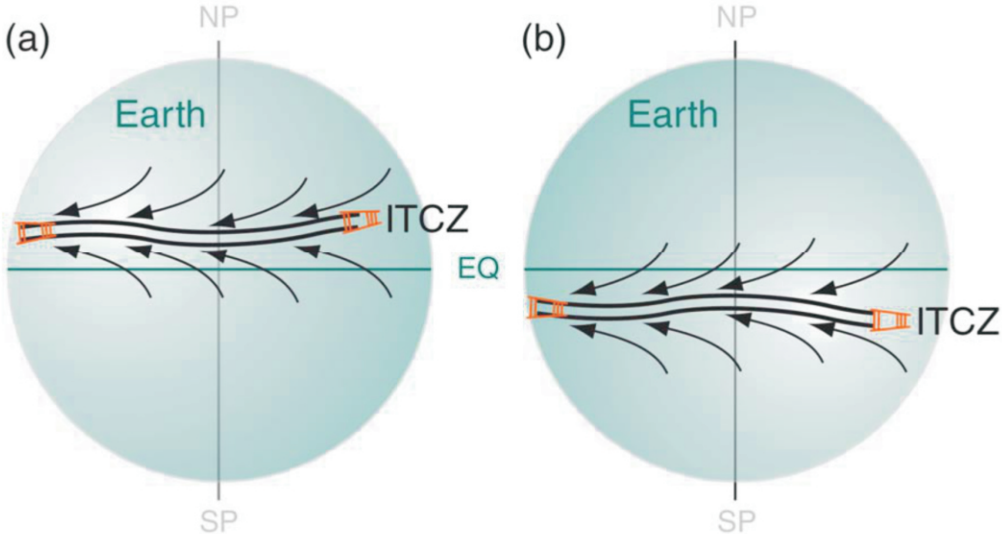

Fig. 2.9 Sketch of the Earth showing the Intertropical Convergence Zone (ITCZ, double solid line) for the early Autumn tropical-cyclone seasons during (a) August and (b) February. NP = North Pole. SP = South Pole. EQ = equator. (Source: Lutgens, F K 2000)

2.3.7.2 Monsoon Trough

Monsoon trough is a part of the Inter Tropical Convergence Zone (ITCZ) where the northern hemisphere and southern hemisphere winds meet into a monsoon circulation and can trigger thunderstorms for cyclone in the Indian Ocean and the Eastern Pacific. Fig. 2.10 shows an example of monsoon trough in the western Pacific highlighting low and high pressure region.

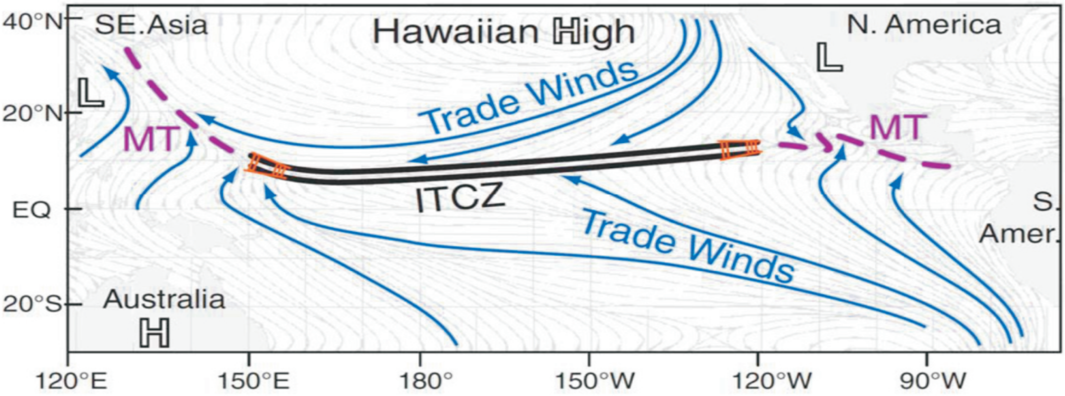

Fig. 2.10 Streamline analysis (blue lines with arrows) of near-surface winds, averaged during August. MT denotes Monsoon Trough, shown by the thick dashed lines. L and H are monsoon lows and highs. [Modified from Naval Research Lab. image]

2.3.7.3 Mid-latitude Frontal Boundary

Mid-latitude cold fronts can sometimes move away from equator hence resulting in sufficient Coriolis effect for the development and intensification of a tropical cyclone. In the mid-latitudes there is a boundary between warm moist air to the south and cold dry air to the north where a counter-clockwise circulation can set up at the surface with a mass convergence in the center.

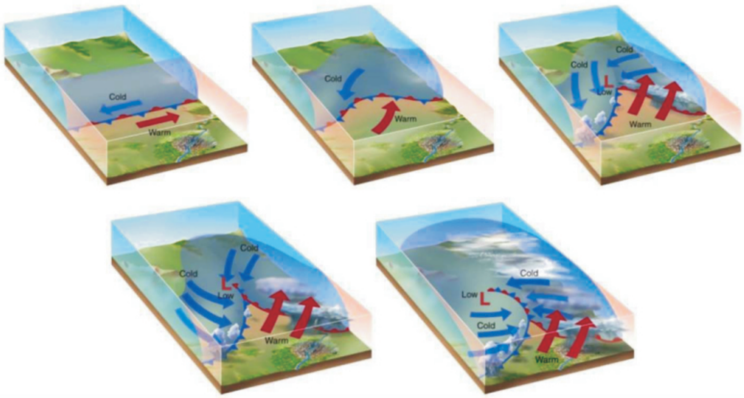

Fig. 2.11 Evolution of a mid-latitude cyclone (Source: Atmos edu, accessed on 13/10/2022)

Above the developing Low-pressure center, there is a region of divergence aloft pulling the air upward and resulting in a surface cyclone. As the cyclone attains maturity, well-defined fronts appear and the eye of the cyclone will have the lowest pressure (Fig. 2.11).

2.3.7.4 Tropical Upper Tropospheric Trough (TUTT)

TUTT also known as the mid-oceanic trough, is a low-pressure system formed at subtropics at high altitude. TUTT to satisfy air mass continuity creates upward motion below it and triggers thunderstorms as precursors to tropical cyclones.

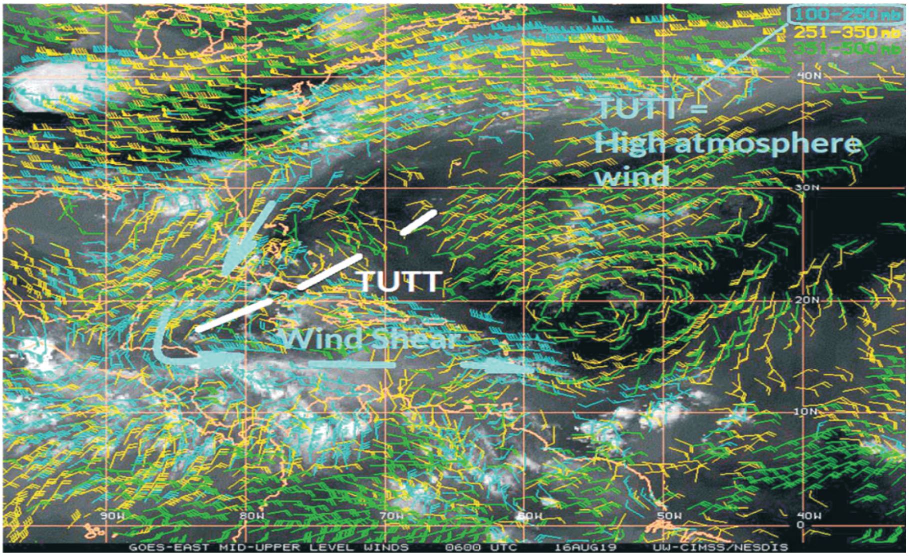

Fig. 2.12 High level wind (above 40, 000 feet and identified with light blue vectors) identify a tropical upper troposphere trough in the Caribbean Sea.

2.4 Cyclone scenario in India

On the basic of frequency of total cyclones, actual/estimated maximum wind strength, total severe cyclones, Probable Maximum Precipitation (PMP), Probable Maximum Storm Surge (PMSS) associated with the cyclones, Regional Specialised Meteorological Centre (RSMC), New Delhi, has prepared cyclone hazard proneness of districts of India (Fig. 2.13 below). Based on the proneness to cyclone, 96 districts has been classified which consist of 72 districts touching the coast the and remaining 24 districts lying within 100 km from the coast but not touching the coastline. Out of 96 districts, 12, 41, 30, 13 are classified as very highly prone, highly prone, moderately prone and less prone respectively. The very high prone districts includes Yanam of Puducherry, Kendrapara, Bhadrak, Balasore, and Jagatsinghpur districts of Odisha, Kolkata, Medinipur, North and South 24 Praganas of West Bengal, Krishna, east Godavari, and Nellore, districts of Andhra Pradesh. Most of the coastal districts of Gujarat and north Konkan are also highly prone districts. In Odisha and Andhra Pradesh, all district that touches the coast (except those that fall on very highly prone) fall under high prone districts. The south coast of Tamil Nadu are less prone compared to the northern coast. The proneness classificaton is prepared based solely on on hazard criteria and location specific vulnerablity was not considered. Hence, a detailed study needs to carried out to understand the composite cyclone risk of a district.

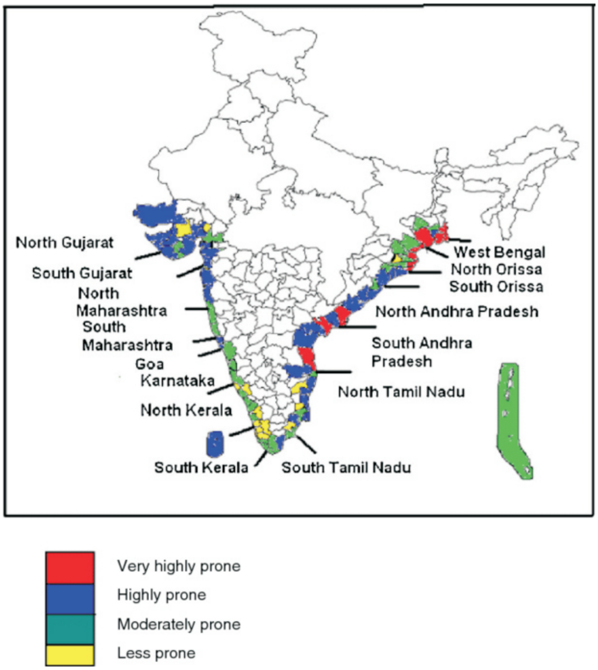

Fig. 2.13 Cyclone hazard prone districts of India (Source: Mohapatra et al. 2012)

2.4.1 Historical cyclones and their impact

The Indian Seas have historically been the deadliest basin with several cyclones responsible for more than 1 lakh of causalities. The 1970 Bhola cyclone killed about 3 lakhs people, perhaps, the maximum number as per the recorded history. Tables 2.4 (a) & 2.4 (b) list some of the most intense TCs that had affected Indian coasts.

Table 2.4 (a) Historical records of most devastating cyclonic storms, which formed in the Bay of Bengal and made landfall on the East coast of India

Sl. No.	Date/Year	Category of Cyclone	Landfall and Relevant information
1.	7–12 October, 1737	Super Cyclonic Storm	Crossed West Bengal coast over Sunderbans Surge height: 12 M
2.	31 October, 1831	Very Severe Cyclonic Storm	Crossed Odisha coast near Balasore Surge height: 2–5 m Loss and damage: People killed - 22,000 Cattle heads lost - 50,000
3.	2–5 October, 1864	Very Severe Cyclonic Storm	Crossed West Bengal coast near Contai Surge height: The maximum height of the waves reached 12 m. Loss and damage, People killed - 50,000 (mostly due to drowning), and 30,000 (due to diseases as a result of inundation)
4.	1–2 November, 1864	Severe Cyclonic Storm	Crossed Andhra Pradesh coast near Machilipatnam Surge height: 4 m. Loss and damage: People killed - 30,000
5.	22 September, 1885	Super Cyclonic Storm	Crossed Odisha coast near False Point, Central pressure: 919 hPa, Surge height: 7 m Loss of life: 5000
6.	14–16 October, 1942	Severe Cyclonic Storm	Crossed West Bengal coast near Contai Surge height: 3 – 5 m Loss and damage: People killed – 19,000 Cattle heads killed - 60,000
7.	8–11 October, 1967	Severe Cyclonic Storm	Crossed Odisha coast between Puri and Paradip on the morning of 9 October and then crossed Bangladesh coast during the night of 10 – 11

Sl . No.	Date/Year	Category of Cyclone	Landfall and Relevant information
			October. Loss and damage: People killed - 1,000, Cattle heads lost 50,000.
8.	26–30 October, 1971	Severe Cyclonic Storm	Crossed Odisha coast near Paradip early morning of 30 October Maximum wind: 150-170 kmph (81-92 kts.) Surge height : 4 – 5 m, north of Chandbali Loss and damage: People killed – 10,000; Cattleheads lost – 50,000; Houses damaged – 8,00,000
9.	14-20 November, 1977	Super Cyclonic Storm	Crossed Andhra Pradesh coast Nizampatnam at 1730 IST on 19 November. Maximum wind: Ongole: 102 kmph (55 kts) Machilipatnam: 120 kmph (65 kts); Gannavaram: 139 kmph (75 kts.) Surge height : 5 m Intensity : T 7.0 Maximum estimated wind speed: 260 kmph (140 kts) Loss and damage: People killed - 10,000; Cattleheads – 27,000; Damage to crops and other property were estimated to be around Rs. 350 crores.
10.	4 – 11 May, 1990	Super Cyclonic Storm*	Crossed Andhra Pradesh coast at about 40 km south west of Machilipatnam around 1900 IST of 9 May Maximum wind : Machilipatnam: 102 kmph (55 kts); Gannavaram: 93 kmph (50 kts) Maximum estimated wind speed : 235 kmph (126 kts) Surge height : 4 – 5 m Intensity : T 6.5 Loss and damage: People killed – 967; the estimated cost of the damages to crops and properties - Rs. 2,248 crores.

Sl. No.	Date/Year	Category of Cyclone	Landfall and Relevant information
11.	5–6 November, 1996	Very Severe Cyclonic Storm	Crossed Andhra Pradesh coast near Kakinada at midnight of 6 November Maximum wind: 200 kmph (108 kts) Surge height : 3 – 4 m Loss and damage : People killed – 2000; People missing - 900; crops destroyed in 3,20,000 hectares of land; house destroyed – 10,000 Estimate of the loss for crops - Rs. 150 crores
12.	25–31 October, 1999	Super Cyclonic Storm	Crossed Odisha coast near Paradip at noon of 29 October. Maximum wind : 260 kmph (140 kts); Bhubaneshwar: 148 kmph (80 kts) Surge height : 6 – 7 m Intensity : T 7.0 Loss and damage : People killed = 9,885; People injured - 2,142; cattleheads perished - 3,70,297, Paddy crops in 16,17,000 hectares and other crop in 33,000 hectares damaged.
13.	April 27 – May 3, 2008	Extremely severe cyclonic storm	became very active over the Bay of Bengal and later spawned a low-pressure area Maximum wind: 165 km/h (105 mph) Surge height : 3 to 5 m Total fatalities: 138,927 total Total damage: ~ $14.7 billion (2008 USD)
14.	17 - 21 May, 2010	Severe cyclonic storm Laila	Made landfall in Andhra Pradesh, and it later dissipated over land Maximum wind: speed100 km/h (65 mph) Total fatalities: 65 total Total damage: $117.49 million (2010 USD)
15.	28 October - 1 November, 2012	Cyclonic Storm Nilam	Made landfall near Mahabalipuram, Chennai Maximum wind speed: 85 km/h (50 mph) Total fatalities: 75 total Total damage: At least $56.7 million (2012 USD)
16.	7 - 14 October, 2014	Extremely Severe Cyclonic Storm Hudhud	Areas affected: Andaman and Nicobar Islands, Andhra Pradesh, Vishakhapatnam, Odisha, Chhattisgarh, Madhya Pradesh, Uttar Pradesh, Nepal

Sl . No.	Date/Year	Category of Cyclone	Landfall and Relevant information
			Maximum wind speed: 215 km/h (130 mph) Total fatalities: 124 Total damage: $3.58 billion (2014 USD)
17.	17 - 18 December 2016	Cyclonic Storm Roanu	Sri Lanka, East coast of India, Bangladesh, Myanmar, Yunnan Maximum speed: 130 km/h (80 mph) Total fatalities: 401 total Total damage: $5.4 billion (2016 USD)
18.	26 April - 5 May, 2019	Extremely Severe Cyclonic Storm Fani	Areas affected: Sri Lanka, Odisha, Andhra Pradesh, East India, Bangladesh, Bhutan Maximum speed: 250 km/h (130 mph) Total fatalities: 89 total Total damage:$8.1 billion (2019 USD)

Source: IMD, 2013, 2021

Table 2.4 (b) Historical records of most devastating cyclonic storms, which formed in the Arabian Sea and made landfall on the West coast of India

Sl. No.	Date/Year	Category of Cyclone	Landfall and Relevant information
1.	16 May 1618	Severe Cyclonic Storm	Crossed near Bombay (Mumbai) coast Loss and damage : People killed - 2,000
2.	30 October – 2 November, 1854	Severe Cyclonic Storm	Crossed near Bombay (Mumbai) coast on 1 November Loss and damage : People killed - 1,000 Property worth crores of rupees perished within four hours.
3.	18 – 23 November, 1948	Severe Cyclonic Storm	Crossed Maharashtra coast near Virar, 72 km north of Bombay (Mumbai) at about 0830 hrs. IST on 22 November. Maximum wind : Colaba: 120 kmph (65 kts) and Juhu: 151 kmph (81 kts.) Loss and damage : Great havoc and heavy loss of life and property and all means of traffic and communication were completely paralysed for two days. A number of small vessels and crafts capsized in the water of Bombay (Mumbai) harbour. Thousands of big trees uprooted and hundreds of buildings and hutments were rendered uninhabitable.

Sl. No.	Date/Year	Category of Cyclone	Landfall and Relevant information
4.	23 – 25 May, 1961	Severe Cyclonic Storm	Crossed Maharashtra coast near Devgad on the night of 24 to 25 May. Loss and damage: 5 Lakhs fruit trees were reported to have been razed to the ground. 1,700 houses completely and 25,000 houses partially damaged.
5.	9 – 13 June, 1964	Severe Cyclonic Storm	Crossed Gujarat coast just west of Naliya during the late forenoon on 12 June. Maximum wind : Naliya: 135 kmph (73 kts); Dwarka: 105 kmph (57 kts); Porbandar: 74 kmph (40 kts) and Veraval: 83 kmph (45 kts.) Surge height : 2 m at Kandla Loss and damage: People killed – 27
6.	19 – 24 October, 1975	Very Severe Cyclonic Storm	Cossed Saurashtra coast about 15 km to the northwest of Porbandar at 1500 hours IST of 22 October Maximum wind : Jamnagar: 160 – 180 kmph (86-97 kts) Porbandar: 110 kmph (59 kts) Surge height : 4 – 6 m at Porbandar and Okha Intensity : T 6.0 Loss and damage: People killed – 85; Several thousands of houses were damaged, Many trees/ electric/telephone poles/roof tops blew; A train was also blown off its rails; loss of property was estimated to be Rs. 75 crores.
7.	31 May – 5 June, 1976	Severe Cyclonic Storm	Crossed Saurashtra coast near Bhavnagar on 3 June. Maximum wind : Ship HAKKON MAGNUS: 167 kmph (90 kts) Loss and damage : People killed - 70 Cattleheads lost – 4500; Houses damaged - 25000 ; Damage estimated to be Rs. 3 crores.
8.	14–20 November, 1977	Very Severe Cyclonic Storm *	Crossed Karnataka between Mangalore and Honavar in the early morning on 22 November. Intensity: T 5.5 Loss and damages : People killed - 72;

Sl. No.	Date/Year	Category of Cyclone	Landfall and Relevant information
			8,400 houses totally and 19,000 houses partially damaged; Loss estimated to be Rs. 10 Crores.
9.	4–9 November, 1982	Very Severe cyclonic Storm	Crossed Saurashtra coast, about 45 km east of Veraval on 8 November Loss and damage: People killed - 507 Livestock perished – 1.5 Lakh; Thousands of houses collapsed
10.	17-20 June, 1996	Severe Cyclonic Storm	Crossed south Gujarat coast between Veraval and Diu in the early morning of 19 June Intensity : T 3.5 Maximum wind : Veraval recorded 86 kmph (46 kts) at 0430 hrs IST of 19 June Storm surge : 5-6 m near Bharuch Loss and damage: People killed – 46 Cattle heads perished- 2113; No. of houses damaged – 29,595, loss of property-Rs. 18.05 Crore
11.	4 – 10 June 1998	Very Severe Cyclonic Storm	Crossed Gujarat coast near Porbandar between 0630 and 0730 hrs IST of 9 June Intensity : T5.0 Maximum wind : Jamnagar : 183 kmph (98 kts) at 0730 hrs IST of 9 June Surge height : 2 – 3 m above the astronomical tide of 3.2 m; Loss and damage: People killed – 1173; People missing – 1774 Loss of property worth to be Rs. 18.65. Crore
12.	9 - 11 November, 2009	Cyclonic Storm Phyan	Areas affected: Sri Lanka, India (Kethi, Tamil Nadu), Pakistan Maximum wind speed: 95 km/h (60 mph) Total fatalities: 20 Total damage: $300 million (2009 USD)
13.	26 November to 6 December, 2017	Very Severe Cyclonic Storm Ockhi	Areas affected Sri Lanka, India, and Maldives Maximum wind speed: 185 kmph Total fatalities: 318 total, 141 missing Total damage: $920 million (2018 USD)

Source: IMD, 2013, 2021

2.4.2 Annual Frequency of cyclone

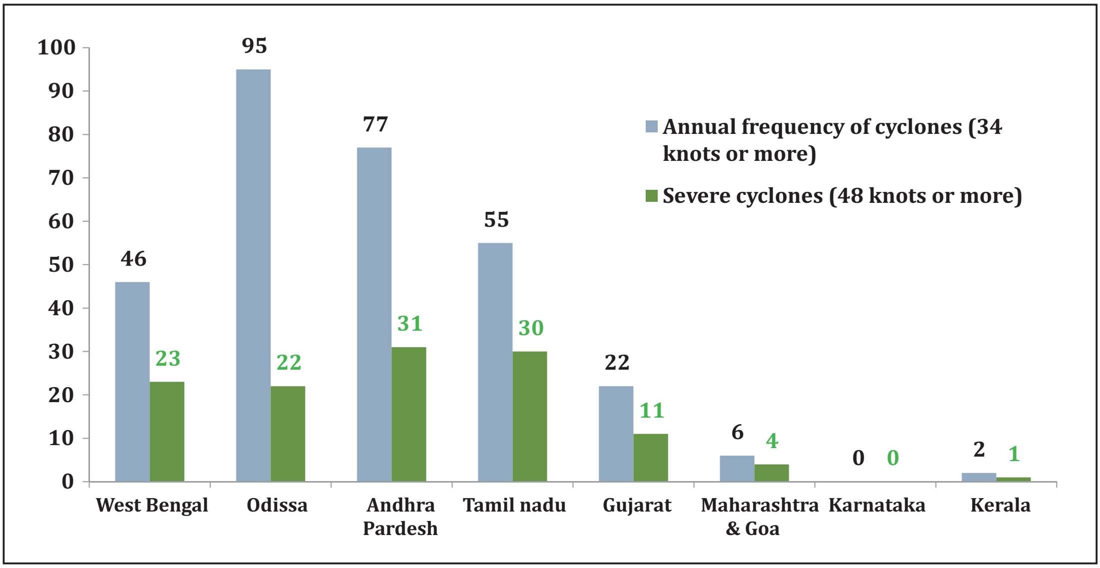

Fig. 2.14 Annual Frequency of cyclone
(Source: IMD, 2018) https://rsmcnewdelhi.imd.gov.in/frequency-of-formation-of-cyclone.php

Sub-Module 3: Cyclone Monitoring and Warning System

3.1 Introduction

The application of early warning systems in landslide is increasingly getting addressed and is hot topic among researchers, scientists, policy makers, stakeholders and professional associated with hazard and risk management. United Nations International Strategy for Disaster Reduction (UNISDR, 2009) defines early warning system as "The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss". Irrespective of the definition, early warning system always aims at reducing the risk of people against disaster with the use of advanced tools, techniques and technologies (Intrieri et al., 2012). In the last 2 – 3 decades, early warning systems have evolved tremendously. The prolonged droughts and famines in 1970s and 1980s in the West African Sahel marked the need of an early warning system (ARPG, 2014). During the Second World Conference on Disaster Reduction in Kobe, Hyogo, Japan in 2006, an agreement called the "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters" (HFA) was negotiated and adopted by 168 countries. This conference mark the paradigm shift of disaster risk management from simply post-disaster response to a more comprehensive approach where prevention, preparedness, assessing and monitoring disaster risks, enhancing early warning systems forms an important component.

Early warning system involves wide range of operation and action right from stages of planning and instrumentation of problematic slopes and landslides to their monitoring, analyses, fixing of early warning alert thresholds, decision making, dissemination of early warning alerts and recurring improvements in early warning practice through sustained location-specific feed backs and new researches. An effective complete early warning system basically consists of four components as follows (UNISDR, 2006):

a. risk knowledge,

b. monitoring and warning service

c. dissemination and communication and

d. response capability

The components are interrelated among each other and any failure or weakness in the system would lead to the failure of the entire system.

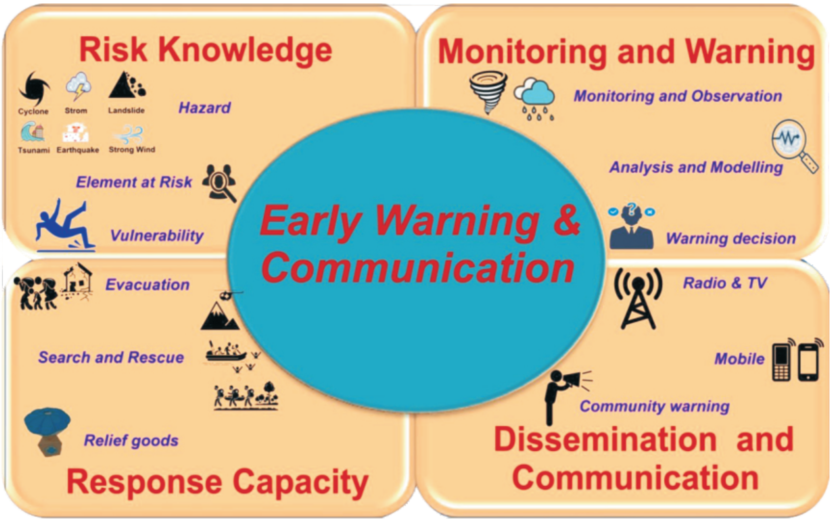

Fig. 3.1 Components of early warning system

3.2 Components of Early Warning Systems

3.2.1 Risk knowledge

To assess the risk, collection, compilation, analysis of data is an essential step considering the variability and dynamic of hazards and vulnerability. Risk in an area is the result of hazard and the vulnerability to hazards that are present in the given area and its assessment helps priorities early warning system. Advancement in research, science and technologies influences greatly the capacity of a nation to carry out hazards assessment of the country and in developing country where such technological advancement is limited, it becomes very difficult to carryout high grade risk assessment. For successful and efficient early warning system, high quality data on location, magnitude, intensity, duration, arrival time and date of hazard event are required. The involvement of community to gather data and statistics, perceived associated risk, formulating coping strategies etc will play an important role in formulating holistic approach towards risk assessment.

Acquisition of data is the preliminary step for risk assessment and at national level several challenges occurs such as establishing, function, maintaining of data collection and observation units, maintaining the quality of data collected along with improvement of historical data, collecting social, economical, environmental data for analysis and insuring institutional mandates.

3.2.2 Monitoring and Warning Services

Monitoring and Warning Services is the core of the early warning chains (Dikau and Weichselgärtner, 2005). For an effective warning system, continuous monitoring of hazards along with hazard influencing factors is essential. The warning massages or prediction of hazards should be backed by scientific proof and the message needs to be dissipated immediately to reach the people at risk at the earliest. The warning can be communicated via several media such as television, radio, SMS, Email, sirens, Fax, community radio and speakers etc. Social and political component of the society also influence the effective early warning system and for it requires carefully planned legal framework; The early warning message to be decapitated should be simply understandable, believable, and is formulated in accordance of the target group providing clear instructions to the people at risk.

In recent years significant advance has been made in the field early warning system. However, there are still some areas that need attentions. Some of the issues that lies ahead are hydro-meteorological monitoring system are inadequate, inadequate level of technical capabilities, lack of appropriate system for several hazards, restricted access to important data, insufficient collaboration among departments and organizations, insufficient communication systems to provide meaningful, accurate and timely early warning and forecasting information.

3.2.3 Dissemination and Communication

The dissemination and telecommunication mechanisms of the information must be robust operational with updates from time to time in the shortest interval. Response time varies from disaster to disaster for example for earthquake it ranges from second to second and in case of the draught it might Range to weeks. In many cases, the same communication system can be employed to more than one type of warning information. In developing countries like India, there are some major challenges and gaps that are faced in dissemination and Communication of warning forecasting. Constraints of resource, institutional inadequate arrangements, clarity in a warning issued, engagement of the private sector results in morning messages not reaching to the people at risk.

3.2.4 Response Capability

Once the early warning is released, the response mechanism involving orderly evacuation of people out of vulnerable areas, temporary relocations, shelters, safely securing assets of evacuated peoples. Preparedness strategies and plans are an integral part of early warning system and it ensures effective response activities in response to forecasting and early warning massages. Based on the warning issued range of actors have to response which must be coordinated with other official or players that are engaged in the event. Various government departments, agencies, national disaster management institutions, state disaster management institutions, district disaster management institutions, community based disaster management institutions, civil defense, NGOs and volunteer involving organizations are key players in response scenario to early warning. Lack of planning and coordination at the national and local levels often leads to the failure to response efficiently to warning messages. Weak public information, limited integration of disaster education in school curriculum, lack of evacuation drills and simulation exercises, limited public's concerns and understanding of vulnerabilities.

3.3 Cyclone Warning Organization

At present, the cyclone warning organization of the India, India Meteorological Department (IMD), has three-tier system to cater to the needs of the maritime states. There are Area Cyclone Warning Centres (ACWCs) at Chennai, Mumbai and Kolkata and Cyclone Warning Centre (CWCs) at Visakhapatnam, Ahmedabad and Bhubaneswar and the details of the centre and the responsibility is represented in Table 3.1. The coordination of cyclone warning operations at the national level is done by the "Weather Central" at Pune whereas the international coordination and liaison with the Central Government organizations and other agencies as well as co-ordination and supervision of cyclone warning activities are done by Cyclone Warning Division (CWD) at New Delhi. CWD, New Delhi is also functioning as Regional Specialized Meteorological Centre - Tropical Cyclones (RSMC - Tropical Cyclones), New Delhi.

Table 3.1 Area of Responsibility of ACWC/CWC

Centre	**Area of Responsibility**		*Maritime State*
	Sea area	*# Coastal area*	
ACWC Kolkata	Bay of Bengal	West Bengal, Andaman & Nicobar Islands.	West Bengal & Andaman & Nicobar Islands.
ACWC Chennai		Tamil Nadu, Pondicherry, Kerala & Karnataka	Tamil Nadu, Puducherry, Kerala, Karnataka & Lakshadweep.
ACWC Mumbai	Arabian Sea	Maharashtra, Goa	Maharashtra, Goa.
CWC Bhubaneshwar	-	Odisha	Odisha
CWC Visakhapatnam	-	Andhra Pradesh	Andhra Pradesh
CWC Ahmedabad	-	Gujarat, Diu, Daman, Dadra & Nagar Haveli	Gujarat, Diu, Daman, Dadra & Nagar Haveli

Source: IMD 2013

3.3.1 Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones, New Delhi

There are five tropical cyclones regional bodies, i.e., ESCAP/WMO Typhoon Committee, WMO/ESCAP Panel on Tropical Cyclones, RA I Tropical Cyclone Committee, RA IV Hurricane Committee, and RA V Tropical Cyclone Committee. Under these regional bodies, there are six RSMCs and the areas of responsibility of different RSMCs are shown in Fig. 3.2. The RSMC is responsible for monitoring and prediction of tropical cyclones over their respective regions. The area of responsibility of RSMC- New Delhi covers Sea areas of north Indian Ocean north of equator between 450 E and 1000 E and includes the member countries of WMO/ESCAP Panel on Tropical Cyclones viz, Bangladesh, India, Maldives, Myanmar, Pakistan, Sri Lanka, Sultanate of Oman and Thailand.

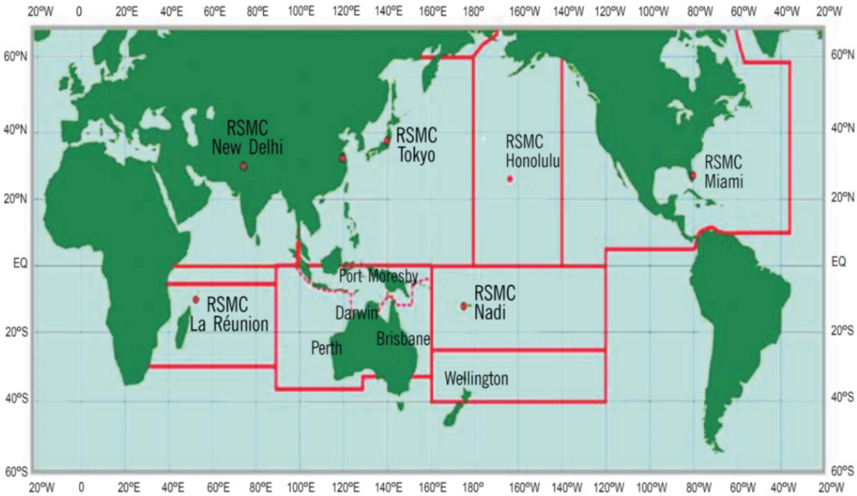

Fig. 3.2 Area of responsibility of different RSMCs and TCCs

3.3.2 Cyclone Warning Division

As per one of the recommendations of the Cyclone Review Committee (CRC), a Cyclone Warning Directorate co-located with RSMC Tropical Cyclones New Delhi was established in 1990 in the Office of the Director General of Meteorology, New Delhi to co-ordinate the cyclone warning work in the country in totality.

Fig. 3.3 Cyclone Warning Organisational Structure of IMD (Source: IMD 2013)

3.3.3 ACWCs/CWCs

The Storm Warning Centres at Mumbai, Chennai and Kolkata were named as Area Cyclone Warning Centres (ACWC) after the establishment of centres at Visakhapatnam and Bhubaneswar. The Storm Warning Centres at Ahmedabad, Bhubaneshwar and Visakhapatnam were called as Cyclone Warning Centres (CWC) and are functional under the ACWCs-Mumbai, Kolkata and Chennai respectively (Fig. 3.3 & Table 3.1).

The cyclone warnings organisational structure is a three-tier structure where the operational works of issuing the bulletins and warnings to the various user interests are performed by ACWCs/CWCs. CWD New Delhi and the Deputy DG of Meteorology (Weather Forecasting) guide and coordinate the work of ACWCs/CWCs. They also supervise the work carried by ACWCs/CWCs and work towards continuous improvement and efficiency of the storm warnings system of the country as a whole.

3.4 Observational Aspects of Cyclone Warning System

Observational network for cyclone forecasting is aimed at continuous monitoring of the horizontal and vertical structure of the atmosphere. Surface and upper air observations from various oceanic and land platforms are the basic data required by a cyclone forecaster.

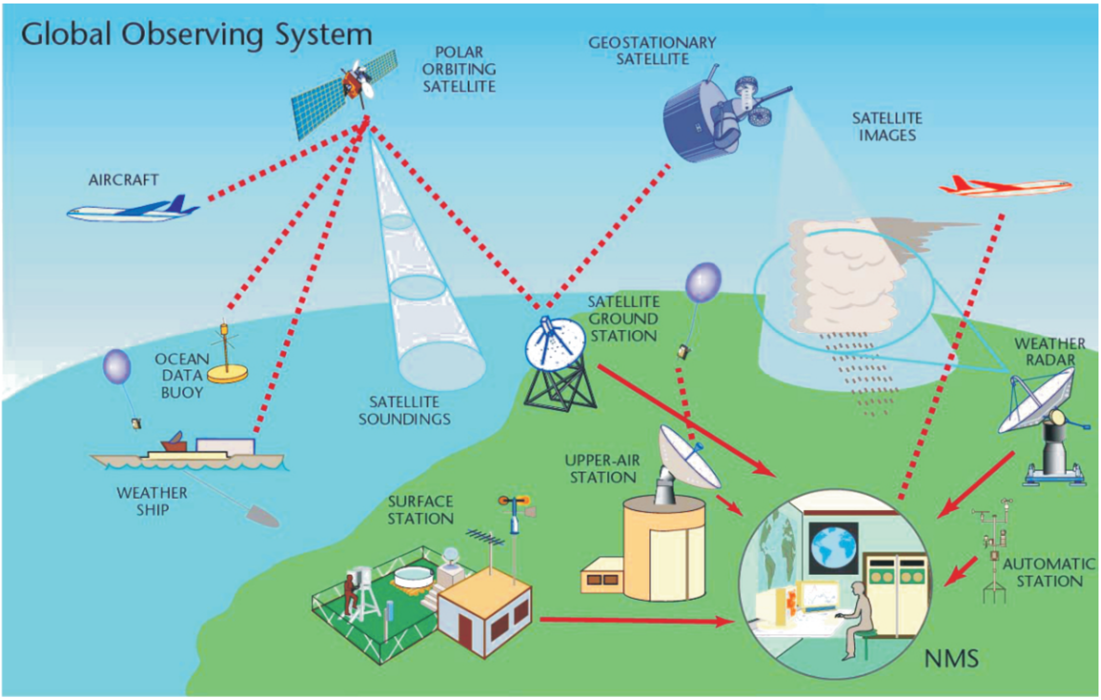

Fig. 3.4 Observational network for cyclone monitoring
(Source: WMO, accessed on 13/11/2022)

3.4.1 Surface Observations

Operational forecasting is carried out using the data generated from 559 surface observatories of IMD (RMSC-New Delhi, 2015). Recently, under the National Data Buoy Programme (NDBP) of the Ministry of Earth Sciences, Government of India, several moored ocean buoys which includes Ocean Thermal buoys, Meteorological Buoy, Deep Sea Buoy and Shallow Water Buoy have been deployed over the Indian Sea.

Additionally, a large number of ship observations (about 50 ships per day), both Indian and International, are received and assimilated in the analysis over Indian seas from about 50 ships per day,

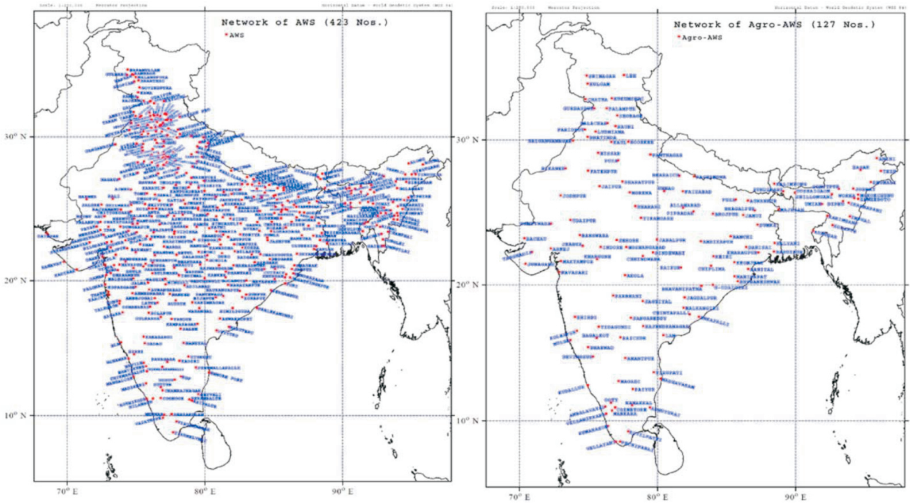

Fig. 3.5 Network of 423 AWS and (b) 127 Agro-AWS established during 2008-2012.

Under the Modernization Program Phase-I, IMD has established a network of 550 automatic weather stations (AWS), and 1350 Automatic Rain Gauge (ARG) Stations. Efforts have been made to have a uniform distribution of network stations throughout the country by installing one AWS in each district of the country. ISRO has installed 20 AWS. For continuous monitoring of high wind speeds along the coast of India, 20 high speed recorders are installed (RSMC, 2019).

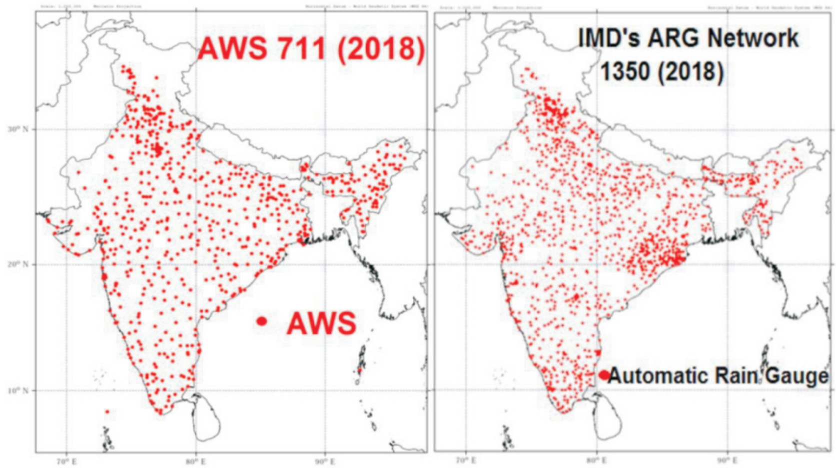

Fig. 3.6 Network of 711 AWS and (b) 1350 ARGs

3.4.2 Upper Air Observatories

At present, India has 43 Radiosonde/ Radio wind observatories and 62 Pilot Balloon Observatories. All the 43 Radiosonde/ Radio wind observatories are latest of the art- GPS based observatories where six RS/RW stations at Regional Meteorological Centre's at Mumbai, New Delhi, Chennai, Kolkata, Nagpur and Guwahati are of Global Climatological Observations System Upper Air Network (WMO-GUAN) standards. A Wind Profiler/Radio Acoustics Sounding System capable of recording upper air temperature up to 3 km and upper wind up to 9 km above Sea level has been installed at Pashan, Pune in collaboration with M/S SAMEER, Mumbai and IITM, Pune. The location of the pilot balloon observation network and RS/RW network of IMD is shown in Fig. 3.7.

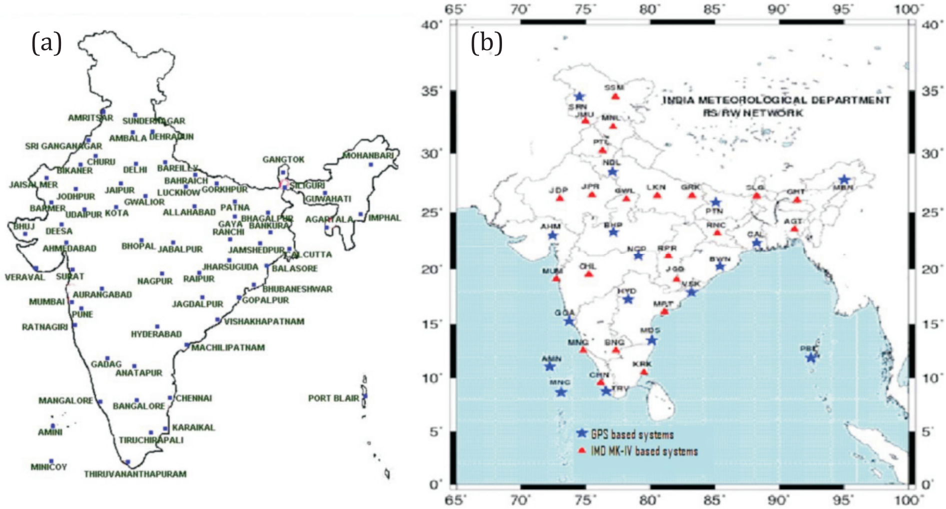

Fig. 3.7(a) Network of Pilot Balloon Observatories (PBO) and
(b) Network of Radiosonde/ Radio wind observatories

3.4.3 Radars

Weather radar and Doppler weather radar (DWR) is a type of radar used to locate precipitation, calculate its motion, and estimate its type. They are the basic and most important tool in weather monitoring and forecasting studies for Nowcasting and Forecasting of various severe weather events.

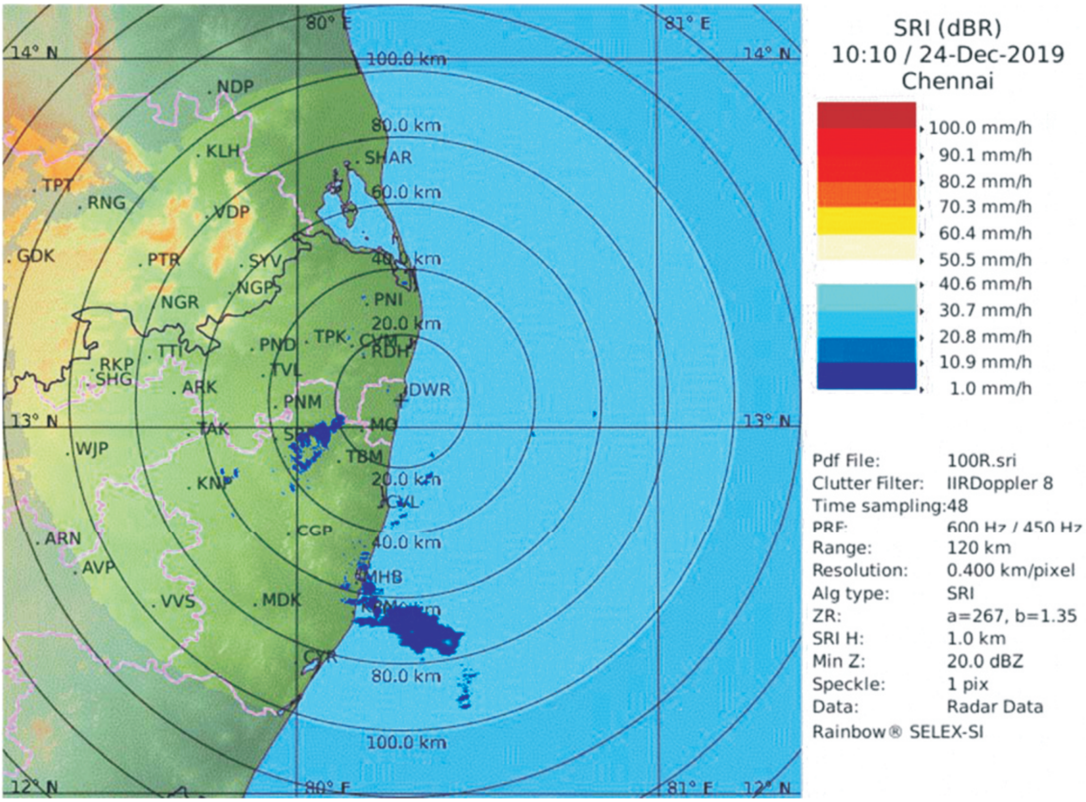

Fig. 3.8 Examples of Radar products (Surface rainfall intensity)
(Source: https://mausam.imd.gov.in/chennai/index_radar.php)

3.4.4 Current status

IMD manages the Weather radar network of India which consists of 24 DWR presently spreading across the country. 21 S-band, 2 C-band and 1 X-band Polarimetric DWRs. At Gopalpur and Kochi 2 indigenously manufactured S-band polarimetric DWRs have been installed. ISRO has installed DWR systems at Cherrapunji, Sriharikota and Thiruvananthapuram.

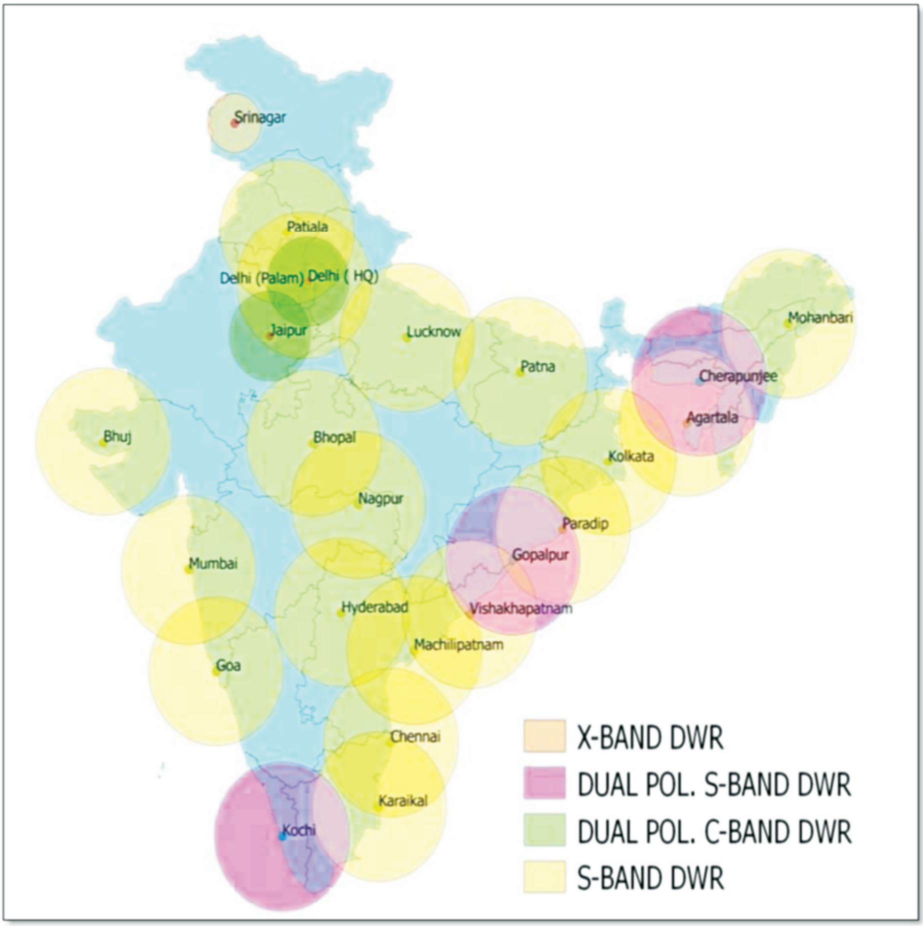

Fig. 3.9 Network of Radar
(Source: https://mausam.imd.gov.in/imd_latest/contents/pdf/pubbrochures/Upper%20Air%20Instrument%20Division.pdf)

The 21 S-band DWRs installed are located at New Delhi, Mumbai, Kolkata, Sriharikota, Lucknow, Hyderabad, Bhopal, Visakhapatnam, Bhuj, Chennai, Patna, Paradeep, Nagpur, Mohanbari, Kochi, Agartala, Machilipatnam, Goa, Karaikal, Patiala, and Gopalpur. C-band Polarimetric DWRs are installed at New Delhi and Jaipur. At Srinagar, X-Band transportable radar has been installed. IMD radars are use for detection of precipitation, thunder storms, hail storm along with the tracking of cyclonic storms. DWR data are used for the derivation of various meteorological and hydrological products using software algorithms, which are very crucial in estimation of intensity, centre and structures of a storm. Numerical weather predictions (NWP) are also carried out in the existing DWRs for short range forecasting. For archival and retrieval of radar data, a National Radar data centre has been established at IMD, New Delhi.

3.4.5 Future Plan

IMD has planned to modernize Radar Network by introducing state of art DWRs in replacement of old conventional Radars. With an aim to cover the entire Country and coasts under DWR coverage, IMD plans to install more than 55 DWRs throughout the country. It is proposed to install 11 C-band radars in the plains of the country and 10 X-band radars in the northwest India including Uttrakhand, Himachal Pradesh and Jammu & Kashmir.

3.4.6 Satellite Monitoring

Satellites are often used in monitoring the weather and climate of the Earth. Satellite can be polar orbiting or geostationary. Meteorological satellites can see beyond clouds and are used for the observation of sand and dust storms, ice mapping, snow cover, fires, boundaries of ocean currents, city lights, effects of pollution, auroras, energy flows, etc.

3.4.6.1 SCATSAT-1

Indian Space Research Organisation launched SCATSAT-1 for ocean and weather related studies and seven co-passenger satellites into polar Sun Synchronous Orbit (SSO) on September 26, 2016. The Indian satellite SCATSAT-1 is a miniature satellite dedicated to ocean wind observation. It is preceded by Oceansat-2 which was also dedicated for the same objective. Major objectives of SCATSAT-1 is weather forecasting, cyclone prediction along with ocean state monitoring and prediction. It is currently catering towards weather and climate sector, naval and shipping operations, renewable energy sector along with tracking services to India as well as to the world.

3.4.6.2 INSAT-3DR

INSAT-3DR is identical to INSAT-3D in terms of Sensors and products. INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellite is monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal. INSAT-3DR is a multipurpose geosynchronous spacecraft with main meteorological payloads (imager and sounder). The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT-3DR is monitoring the earth's surface, oceanic observations and also provide data dissemination capabilities. It provides Broadcast Satellite Services (BSS) through two S-band transponders. The data acquisition and processing system is established at Space Applications Centre, Bopal Campus, Ahmedabad, India. The processing of INSAT-3DR data is taken place broadly in four steps. It is positioned at 74º East Longitude.

a) Ground receiving system to receive data

b) Data Reception (DR) system to generate raw data (L0) files

c) Data Processing (DP) system to process L0 data and produce L1B data files (Calibrated and Geo located)

d) Product generation and Dissemination system

The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT-3DR will Monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities, Provide Broadcast Satellite Services (BSS) through two S-band transponders.

3.4.6.3 KALPANA-1

Metsat is an exclusive meteorological satellite of ISRO in geo-synchronous orbit. Metsat was launched on- board upgraded and modified satellite launch vehicle

(PSLV) with a lift–off mass of 1060 kgs in September 2002. After successful launch and early orbit operations and in orbit characterization of the Payload, the satellite has been commissioned for routine usage of weather data and imageries. Major Metsat/Kalpana mission objectives are:-

- To establish a small satellite I-1000 bus system which can meet the exclusive service requirements of a meteorological payload for earth imageries.
- Collection of weather data from low cost unattended data collection platforms-to configure Metsat spacecraft within the lift-off mass constraints of upgraded existing polar satellite launch vehicle for deployment in Geo-synchronous Transfer Orbit (GTO) mission.

3.4.6.4 INSAT-3A

INSAT-3A is a multipurpose satellite for providing telecommunications, television broadcasting, meteorological and search & rescue services. It carries twenty four transponders - twelve operating in the normal C-band frequency, six in Extended C-band and six in Ku-band. Nine of the twelve normal C-band transponders provide expanded coverage and the remaining three have India coverage beam. All the extended C-band as well as the Ku-band transponders has India coverage beams. INSAT-3A also carries a Ku-band beacon. For meteorological observation, INSAT-3A carries a three channel Very High Resolution Radiometer (VHRR) with 2 km resolution in the visible band and 8 km resolution in thermal infrared and water vapour bands. In addition, INSAT-3A carries a Charge Coupled Device (CCD) camera which operates in the visible and short wave infrared bands providing a spatial resolution of 1 km. A Data Relay Transponder (DRT) operating in UHF band is incorporated for real time hydro-meteorological data collection from unattended platforms located on land and river basins. The data is then relayed in extended C-band to a central location. INSAT-3A also carries another transponder for Satellite Aided Search and Rescue (SAS & R) as part of India's contribution to the international Satellite Aided Search and Rescue programme. INSAT-3A was launched by European Ariane-5G Launch Vehicle into a Geosynchronous Transfer

Orbit (GTO) with a perigee of 200 km and an apogee of 35,980 km. The satellite is maneuvered to its final orbit by firing the satellite's apogee motor. Subsequently, the deployment of solar array, antennae and the solar sail is carried out and the satellite is commissioned after in-orbit checkout. The data is used to provide

- Telecommunications
- Television broadcasting
- Meteorological
- Search and Rescue services

3A-CCD-COMPOSITE-NDV	10 day composite, normalized difference vegetation index
3A-CCD-NDV	Normalized difference vegetation index
3A-CCD-L1	Level1B data of all channels - Vis, SWIR & NIR
3A-CCD-AOD	Aerosol Optical Depth over Ocean
3A-CCD-GPS	Co-registered Level1B data for all 3 bands data

Products from CCD

Products from VHRR

- 3A VHRR L1B Indian Sector - all 3 channels, VIS, IR and WV
- 3A VHR L1 - every acquisition of 3AVHRR data

- **DATA PRODUCTS**

Short Name	Long Name
K1-VHR-OLR	Outgoing Longwave Radiation derived from IR & WV channels
K1-VHR-WVWV	Water Vapour Winds derived from WV channel
K1-VHR-CMV	Cloud Motion vector derived from IR channel
K1-VHR-DAILYSST	Daily Sea Surface Temperature derived from IR channel
K1-VHR-DAILYOLR	Daily Outgoing Longwave Radiation derived from IR & WV channels

Short Name	Long Name
K1-VHR-L1-INDIAN SECTOR	Level1B data for Indian sector for all 3 channels, Water Vapour, Infra Red and Visible
K1-VHR-UTH	Upper Tropospheric Humidity derived from IR channel
K1-VHR-QPE	Quantitative Precipitation Estimation based on GPI algorithm and derived using IR channel
K1-VHR-SST	Sea Surface Temperature derived from IR channel
K1-VHR-DAILYQPE	Daily Quantitative Precipitation Estimation based on GPI algorithm & derived using IR channel
K1-VHR-L1	
K1-VHR-AMV	Cloud Motion Vector and Water Vapour Winds
K1-VHR-BRT	IR Brightness Temperature
K1-VHR-BTW	Water Vapour Brightness Temperature
K1-VHR-CMK	Cloud Mask derived using IR channel data
K1-VHR-SGP	
K1-VHR-IMR	INSAT multi channel rain
K1-VHR-SGP-CMV	Cloud Motion Vector
K1-VHR-SGP-WVWV	Water Vapour
K1-VHR-LST	Land Surface Temperature
K1-VHR-DAILYINS	Daily Insolation
K1-VHR-INS	Insolation

3.4.6.5 Megha Tropiques

Megha-Tropiques is an Indo-French Joint Satellite Mission for studying the water cycle and energy exchanges in the tropics. The main objective of this mission is to understand the life cycle of convective systems that influence the tropical weather and climate and their role in associated energy and moisture budget of the atmosphere in tropical regions. Megha-Tropiques provides scientific data on the contribution of the water cycle to the tropical atmosphere, with information on condensed water in clouds, water vapour in the atmosphere, precipitation, and evaporation. With its circular orbit inclined 20 deg to the equator, the Megha-Tropiques is a unique satellite for climate research that should also aid scientists seeking to refine prediction models. The Megha-Tropiques has day, night and all-weather viewing capabilities; it passes over India almost a dozen times every day, giving scientists an almost real- time assessment of the evolution of clouds. The main objective of the Megha-Tropiques mission is to study the convective systems that influence the tropical weather and climate. The Megha-Tropiques mission goals are as follows:

- To provide, simultaneous measurements of several elements of the atmospheric water cycle (water vapour, clouds, condensed water in clouds, precipitation and evaporation),
- To measure the corresponding radiative budget at the top of the atmosphere,
- To ensure high temporal sampling in order to characterize the life cycle of the convective systems and to obtain significant statistics.

Data Products

The MEGHA-TROPIQUES satellite is dedicated to the study of the atmospheric water cycle and energy budget in the tropical atmosphere. Its orbit, slightly inclined relative to the equator (20°), allows it to obtain measurements with an excellent revisit rate. The satellite carries four instruments:

a) The MADRAS microwave radiometer, the mission's main instrument, designed to measure precipitation and cloud characteristics,

b) The SAPHIR microwave radiometer sounder, for calculating the vertical profiles of water vapour in the atmosphere,

c) The SCARAB broadband optical radiometer, for measuring radiation fluxes at the top of the atmosphere,

d) The GPS radio-occultation receiver, for determining atmospheric temperature and humidity.

3.4.6.6 SARAL-AltiKa

SARAL mission results from the common interest of both CNES and ISRO in studying ocean from space using altimetry system and in promoting maximum use of the ARGOS Data Collecting System. Radar altimetry by satellite is a technique used in oceanography to measure, globally over the oceans, the sea level needed to understand ocean circulation and its variability. The importance of altimetry data to better understand the ocean circulation and its impact on the climate of the Earth led to the TOPEX/Poseidon and Jason series of satellites complemented by ERS1-2, GFO and ENVISAT. With the launch of these missions began a data collection that must continue well into the century in order to monitor the inter-annual evolution and separate transient phenomena from secular variations. SARAL/AltiKa mission belongs to the global altimetry system and then participates to the precise and accurate observations of ocean circulation and sea surface elevation for its life time. Thus it is the aim of AltiKa part of the SARAL mission to provide altimetric measurements designed to study ocean circulation and sea surface elevation with the same accuracy as the one provided by ENVISAT mission and complementary to Jasons mission. The AltiKa project developed by CNES is based on a large Ka-band altimeter (35.75 GHz, 500MHz), 1st oceanographic altimeter using such a high frequency. The use of the Ka-band frequency will supply more accurate measurements (improvement of the spatial and vertical resolution) enabling a better observation of ices, coastal areas, continental water bodies as well as the waves height. The drawback of this Ka-band frequency is its sensitivity to rain that can lead to signal attenuation. The SARAL/AltiKa mission is part of the operational satellite altimetry system, jointly with Jason-2, and enables to ensure the service continuity which is nowadays provided by ENVISAT altimeter jointly with Jason-2 and Jason-1. By ensuring the observations continuity and widening the observation areas, CNES answers the wish of the oceanography community by bringing a description: For the meso-scale in open ocean,, In coastal areas, For the seasonal forecast, For the hydrology, For the climate studies. AltiKa data will thus contribute, along with data from others altimetry missions, to the development of operational oceanography, to our climate understanding and to the development of forecasting capabilities through data assimilation methods improvement in coupled oceanatmosphere coupling models, bio-chemistry models, etc

SARAL/AltiKa main scientific objective is to provide data products to oceanographic research user community in studies leading to improve our knowledge of the ocean meso-scale variability, thanks to the improvement in spatial and vertical resolution brought by SARAL/AltiKa.

Ocean meso-scale variability is defined as a class of high-energy processes, with wave lengths within a 50km to 500km range, and with periods of a few days to one year. Kinetic energy of mesoscale variability is one order of magnitude more than mean circulation's one. Description of mesoscale is thus essential for understanding ocean dynamics, including mean circulation and its climatic effects (through interactions of meso-scale turbulence with the mean flow).

SARAL/AltiKa main scientific objective is divided in sub-themes including:

- Intrinsic scientific studies of ocean at meso-scale dynamics: observations, theoretical analyses, modelling, data assimilation, parameterization,
- Improvement of our understanding of the oceanic component in the climate system: investigation of local processes at small or medium scale poorly known and understood at present, but which have an impact on the modelling of climate variability at large spatial and temporal scales.
- Contribution to the study of coastal dynamic processes, especially small or medium scale phenomena, whose retrieval will enable to anticipate many downstream applications.
- Contribution to operational oceanography which is seeking large amounts of in situ and space observation data.

SARAL/AltiKa secondary objectives are notably the monitoring of the main continental waters level (lakes, rivers, closed seas), the monitoring of mean sea level variations, the observation of polar oceans, the analysis and forecast of wave and wind fields, the study of continental ices (thanks to improved performances of Ka-band) and sea ices, the access to low rains climatology (enabled in counterpart to the sensitivity of Ka-band to clouds and low rains) and the marine biogeochemistry (notably through the role of the meso and sub-meso-scale physics).

3.4.6.7 Oceansat-2

Oceansat-2 satellite mainframe systems derive their heritage from previous IRS missions. Oceansat-2 was launched by PSLV-C14 from Satish Dhawan Space Centre, Sriharikota on Sept. 23, 2009. It carries three payloads: Ocean Colour Monitor (OCM) Ku-band Pencil Beam scatterometer (SCAT) developed by ISRO Radio Occultation Sounder for Atmosphere (ROSA) developed by the Italian Space Agency. Oceansat-2 is envisaged to provide continuity of operational services of Oceansat-1(IRS-P4) with enhanced application potential. The Indian satellite Oceansat-2 is designed to provide service continuity for operational users of the Ocean Colour Monitor (OCM) instrument on Oceansat-1. It will also enhance the potential of applications in other areas. The main objectives of OceanSat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water. The primary mission objectives of Oceansat-2 are:

a) To design, develop, launch and operate a three axis stabilized spacecraft carrying an Ocean Colour Monitor and Ku-band Scatterometer,

b) To develop / implement algorithms for retrieval of geophysical parameters like wind vector on an operational basis.

c) To promote new applications in the areas of ocean studies including prediction of cyclone trajectory, fisheries, coastal zone mapping etc.

Oceansat-2 gathers systematic data for oceanographic, coastal and atmospheric applications. The main objectives of OceanSat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water.

3.5 Analysis and Nowcasting

Prediction of tropical cyclone is a complex process which includes prediction of several parameters such as location, wind speed, intensity, probable storm surges and accompanying rainfall etc (Holland, 2009; Roy and Kovordanyi, 2012). Tropical cyclone forecasting techniques takes into consideration the behavior of previously encountered similar cyclone and/or the recent-past behavior of the current cyclone. The similarity between cyclones may be attributed to the similar behavioral pattern, place of origin or time of origin. To forecast the track of the current cyclone, certain forces or factors are considered, also called predictors, with an assumption that these predictors would influence the previous and present cyclone in similar manner.

The forecasting and prediction techniques and instrumentation are constantly improving. Some of recent introduction includes dense automatic weather station (AWS) network, good network of Doppler Weather Radars, Kalpana and INSAT satellites observations, advancement in analysis tools, availability of nowcast models, computational and communication capabilities etc. for nowcasting of convective weather major stations/cities falling under the coverage of DWR and with the expansion of DWR networks, more number of cities will be brought under nowcasting.

3.6 Warning and bulletins

3.6.1 RSMC, New Delhi

RSMC, New Delhi prepares and disseminates the following bulletins.

3.6.1.1 Tropical Weather Outlook

Under normal weather conditions, Tropical Weather Outlook is issued by RSMC daily at 06:00 am Universal Time Coordinated (UTC) on the basis of observation made on 0300 UTC and contain information on synoptic systems over north Indian Ocean (NIO). In addition, it contains information collected via satellite imageries and ridge line at 200 hPa level regarding significant cloud systems over Indian region. When a tropical depression lies over north Indian Ocean, RSMC also issue a Special Tropical Weather Outlook at 1500 UTC based on 1200 UTC observations.

3.6.1.2 Tropical Cyclone Advisories

Tropical cyclone advisories are issued at 3 hourly intervals based on 00, 03, 06, 09, 12, 15, 18 and 21 UTC observations and the issue time is HH+03 hrs. These bulletins contain vital information such as position, direction, speed, central pressure, expected intensity and probable track of cyclone (IMD). State of the Sea in and around the system, forecast of Storm surge, wind and adverse weather is also provided. IMD makes the Tropical cyclone advisories available on real time basis through their website: http://www.imd.gov.in

3.6.1.3 Storm surge guidance

Storm surge guidance for are transmitted to WMO/ESCAP panel member Countries via global telecommunication system (GTS) based on INCOIS and IIT, Delhi models as and when required. The graphical model derived output is provided in IMD website.

3.6.1.4 Tropical Cyclone Advisory for international aviation

RSMC, New Delhi also issue tropical cyclone advisories for civil aviation by Tropical Cyclone Advisory Centre (TCAC). RSMC, New Delhi issue these bulletins when intensity of cyclonic storm i.e., sustained surface wind speed $\geq$ 34 is knots attains or likely to attain any disturbance over the north Indian Ocean. These bulletins contain important information such as present location of cyclone, estimated central pressure, maximum sustained surface wind, past direction, forecast position and wind speed. These bulletins are issued at six hourly intervals based on 00, 06, 12, 18 UTC synoptic charts and the time of issue is HH+03 hrs. GTS and AFTN channels are used to transmit these tropical cyclone advisories to designated International Airports of the region prescribed by International Civil

Aviation Organisation (ICAO) on real time basis. Tropical cyclone advisories issued by RSMC, New Delhi are shared with Aviation Disaster Risk Reduction (ADRR) centre of WMO at Honkong and also uploaded in IMD website.

3.6.1.5 Regional Cyclone Operational Plan

Annual Tropical Cyclone Operational Plan for the north Indian Ocean is prepared by RSMC, New Delhi which is published by WMO and circulated to all Member countries. Annual Tropical Cyclone Operational Plan mainly deals with the standard operation procedure (SOP) for early warning of tropical cyclone over the north Indian Ocean by different WMO/ESCAP Panel member countries.

3.6.1.6 Annual Cyclone Review Report

Annual Cyclone Review Report is prepared by RSMC, New Delhi by collecting the inputs from the WMO/ESCAP Panel countries. Annual Cyclone Review Report contains five main activities of Panel member countries, viz., hydrological activity, disaster preparedness and prevention (DPP) activities, meteorological activity, research activities and training activities. It also contain annual operational plan published and circulated by WMO. It is also available in IMD website.

3.6.1.7 Press release

A press conference is held as and when required under the chairmanship of Director General of Meteorology, IMD at New Delhi well in advance for the press and electronic media. All the information such as present location of the cyclone, estimated central pressure, wind speed, maximum sustained surface wind, past direction, landfall point & time, heavy rain, gale wind & storm surge, expected damage, action suggested etc.

3.6.2 Cyclone Warning Division (CWD)

In 1990 a Cyclone Warning Directorate was created in the Office of the DG of Meteorology, New Delhi with the recommendations of the Cyclone Review Committee (CRC). The Cyclone Warning Division (CWD) coordinates the cyclone warning related work in the country and is collocated with RSMC-Tropical Cyclones, New Delhi.

3.6.2.1 Bulletin for Indian coasts

Bulletin for Indian coasts are issued from the stage of depression onwards based on 00, 03, 06, 12, and 18 UTC observations. On extreme weather, these bulletins are issued at 00, 03, 06, 09, 12, 15, 18 and 21 UTC (every three hourly interval) and the issue time is HH+3 hours. The bulletin issued contain important information such as present location of the cyclone, estimated central pressure, wind speed, maximum sustained surface wind, past direction, forecast position and movement for next 72 hours. The bulletins also contain information regarding likely landfall point & time, heavy rain, gale wind & storm surge, expected damage, action suggested etc. This bulletin issued is disseminated through various modes of communication such as All India Radio (AIR), electronic media, Print, Telephone, Fax, e-mail, IMD website (http://www.imd.gov.in) etc and is meant for national users.

3.6.2.2 Bulletin for high officials

This bulletin is issued from pre-cyclone watch stage onwards i.e., 72 hrs in advance of commencement of adverse weather along the coast issued once a day based on 0300/0600 UTC. This bulletin is circulated to national level disaster managers, cabinet secretary, National Disaster Management, Minister of Home Affairs, National Disaster Management Authority, All India Radio, Door Darshan, Ministry of Defense etc.

3.6.2.3 Handbook on Cyclone Monitoring, Forecasting and Services

This includes systematic steps required for monitoring of cyclone, forecasting and dissemination services. During cyclone scenario, it serves as a useful guide for cyclone forecasters.

3.6.3 ACWCs/CWCs

Cyclone warnings are provided by the India Meteorological Department from the Area Cyclone Warning Centres (ACWCs) at Calcutta, Chennai and Mumbai and Cyclone Warning Centres (CWCs) at Vishakhapatnam, Bhubaneshwar and

Ahmedabad. The cyclone warning process is coordinated by the Weather Central in the office of DGM (Weather Forecasting) at Pune and the Northern Hemispheric Analysis Centre at New Delhi. Cyclone Warning Bulletins are provided to the Doordarshan and Air India Radio stations for inclusion in the National broadcast/telecast.

3.6.4 Stages of Warning

The cyclone warnings are issued by the IMD in four different stages namely

1. Pre-cyclone watch
2. Cyclone alert
3. Cyclone warning
4. Post landfall outlook

3.6.4.1 Pre-cyclone watch stage

Pre cyclone watch is also referred as the first stage of cyclone warning system. It contains early warning regarding cyclonic disturbance development in the north Indian Ocean and issued 72 hours in advance. Director General of Meteorology issues the early warning bulletin and is addressed to the Cabinet Secretary, Chief Secretaries of concerned maritime states and other senior officers of the Government of India.

3.6.4.2 Cyclone alert stage

Cyclone Alert stage is the second stage of the cyclone warning system and is usually issued at least 48 hrs in advance of the expected commencement of adverse weather over the coastal areas. The warnings dissipated in this stage contain information on the location, intensity, direction, intensification of stroms. In addition, Cyclone Alert is issued by concerned ACWCs/CWCs and CWD at HQ and contains information about the districts that are likely to experience adverse weather, advices to general public, fishermen, media and disaster managers.

3.6.4.3 Cyclone warning stage

Cyclone warning stage or the third stage warning is issued by the concerned ACWCs/CWCs and CWD at HQ 3 hourly interval issued at least 24 hours in advance of the expected commencement of adverse weather over the coastal areas. Landfall point is forecast at this stage. The warning issued in this stage contains information about the latest position of cyclone, cyclone intensity, details of likely time and point of landfall, associated heavy rainfall, strong wind and storm surge along with their impact and advice to general public, media, fishermen and disaster managers.

3.6.4.4 Post landfall outlook

Post landfall outlook also known as the fourth stage of cyclone warning is issued at least 12 hours in advance of expected time of landfall by the concerned ACWCs/CWCs/and CWD at HQ and contains information regarding direction of movement of the cyclone after its landfall and adverse weather likely to be experienced in the interior areas.

To represent the different stages of cyclone different color codes are used as represented in table.

Stage of warning	**Colour code**
No warning	Green
Cyclone Alert	Yellow
Cyclone Warning	Orange
Post landfall out look	Red

Concerned ACWCs/CWCs warns the ports that are likely to be affected by advising the port authorities through port warnings to hoist appropriate Storm Warning Signals. "Fleet Forecast" are issued by the IMD for Indian Navy and Coastal Bulletins for Indian coastal areas covering up to 75 km from the coast line and sea area bulletins for the sea areas beyond 75 km. in normal weather condition, special warnings are issued for fisherman 4 times a day and in case of disturbed weather, warning are issued every 3 hourly.

3.6.5 Sea Area Bulletin

ACWC Kolkata issue the Sea area bulletins for Bay of Bengal and coastal radio stations at Chennai (VWM) and Kolkata (VWC) broadcast the Sea area bulletins. Coastal radio station at Mumbai (VWB) broadcast the Sea area bulletins issued by ACWC Mumbai for Arabian Sea. Under normal condition, two daily bulletins are issued and in case of disturbed weather, a extra third bulletin is broadcast as and when required.

3.6.6 Warnings to Ports

In adverse weather with probability of tropical cyclone occurrence, ports are warned and advised to hoist "Signals"by the IMD via ACWCs/CWCs. The warning message transmitted to the port contains vital information such as location, intensity, direction, intensification of storms, expected weather over the port etc. ACWCs/CWCs sends high priority telegrams to the port officers who hoist appropriate visual signals prominently on signal masts so that they are visible from a distance for the mariners and other sea-faring people, including fishermen.

3.6.7 Warnings for Fisheries

ACWCs/CWCs issue warning for Fisheries whenever there are bed weather conditions (expected wind speed $\geq$ 45 kmph) such as squally weather, gales, strong monsoon and off shore winds. About 30 AIR stations in the maritime states receive these warning by landline telegram or over Telephone. AIR stations broadcast these warnings four times a day (morning, mid-day, evening, night) in the local language. The warning issued to AIR is more frequent at hourly or 3 hourly intervals for frequent broadcast and the fishermen via portable radio receiving sets can listen to these broadcasts. Telefax are also used to send direct warning messages to officials belonging to the fisheries departments in maritime states.

3.6.8 Coastal Weather Bulletins

Coastal Weather Bulletins are issued by the ACWCs Kolkata, Chennai, Mumbai and CWCs Visakhapatnam, Bhubaneshwar and Ahmedabad for the different coastal areas under their responsibility for the benefit of ships sailing close to the coast. NAVTEX stations broadcast these bulletins in plain language from the 11 coastal DOT radio stations. Out of the 11 coastal DOT radio stations, there are 6, 4 and 1 radio stations located in the west coast, east coast and Andaman and Nicobar Islands respectively. In addition, these bulletins are broadcast in Morse code as well.

3.6.9 Fleet Forecast for Indian Navy

Fleet Forecasts are issued twice daily, corresponding to Aurora and Balloon sea area bulletins exclusively for broadcast to Indian Naval ships through Naval W/T stations since Naval ships normally do not keep watch on commercial W/T wavelengths. The details of areas of responsibility are represented in figure below (IMD, 2023) of different offices to issue Fleet forecasts is represented in Fig. 3.10.

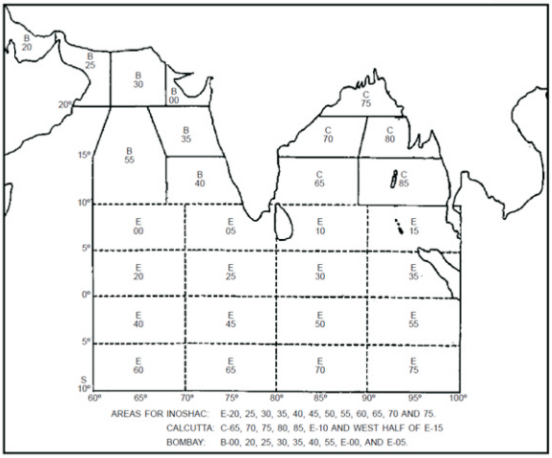

Fig. 3.10 Map showing areas for fleet forecast issued by IMD (Source: IMD, 2023)

3.6.10 Bulletins for All India Radio (AIR)

AIR stations also broadcast cyclone warnings. When the cyclone is more than 400 km away from the coast i.e., beyond the detection range of the coastal cyclone detection radar, AIR stations receives cyclone warnings 6 times a day and each warning is broadcast at frequent intervals interrupting the routine programme. AIR stations are issued hourly cyclone warning when the cyclone comes within the radar range and is tracked by the radar hour to hour.

Arrangement has also been made with AIR New Delhi for Coastal weather bulletins broadcast for the different coastal belts three times a day, viz., in the morning, midday and at night in local languages, Hindi and English.

3.6.11 Press Bulletins

During periods of cyclonic storms, special press bulletins are issued for giving publicity and spreading awareness to cyclone warnings.

3.7 Cyclone Warning Dissemination

Cyclone warnings are disseminated to various users through different means such as Telephone, Tele-fax, VHF/HFRT, Satellite-based cyclone warning dissemination system (CWDS), Police Wireless, AFTN (Aviation), Internet (e-mail), Websites, Radio/TV network, Mobile Phones, Interactive Voice Response System (IVRS), SMS, warnings/advisories are put in the website, www.imd.gov.in of IMD (IMD 2013).

3.7.1 Cyclone Warning Dissemination System (CWDS)

In addition to the above network, for quick dissemination of warning against impending disaster from approaching cyclones, IMD has installed specially designed receivers within the vulnerable coastal areas for transmission of warnings to the concerned officials and people using broadcast capacity of INSAT satellite. This is a direct broadcast service of cyclone warning in the regional languages meant for the areas affected or likely to be affected by the cyclone. There are 352 Cyclone Warning Dissemination System (CWDS) stations along the Indian coast; out of these 101 digital CWDS are located along Andhra coast.

3.7.2 Digital Meteorological Data Dissemination

IMD transmits processed imagery, meteorological and facsimile weather charts to field forecasting offices distributed over the country using the Digital Meteorological Data Dissemination (DMDD) facility, through INSAT in broadcast mode.

3.7.3 Common Alerting Protocol (CAP)

CAP is an XML-based data format for exchanging public warnings and emergencies between alerting technologies. CAP allows a warning message to be consistently disseminated simultaneously over many warning systems to many applications, such as Google Public Alerts and Cell Broadcast. CAP increases warning effectiveness and simplifies the task of activating a warning for responsible officials.

Sub-Module 4: Public Health Emergencies during Cyclone Disaster

4.1 Frequency and timing of disease seen in post-cyclone environments

Infections, non-communicable diseases (NCDs), and injuries are among the health issues that have been linked to an increase in post-cyclone environments. The first four weeks after a cyclone are when these health issues increase the most. The most frequent health issues seen in post-cyclone areas between 1985 and 2014are listed in Table 4.1 in priority order.

Table 4.1: Details of health problems and their timing seen in the post-cyclone scenario

Health Problems	Remarks
Water-borne infections – infectious diarrhoea, shigellosis, cholera, norovirus, leptospirosis	Peaks at Day 5 post-cyclone; comes down by Week 5; however, outbreaks have occurred up to 3—8 months after cyclones.
Acute respiratory diseases	Increase, especially in children. Overcrowding in the evacuation camps favours an increase in respiratory infection
Undifferentiated febrile illness	Up to 4 weeks after storms
Skin and soft tissue infections	Up to 4 weeks after storms
Vector-borne diseases	Increase in the vector population will happen gradually as flood waters recede and leave pools of stagnant water. It also takes some time for other vectors and rodents to multiply to nuisance or hazardous levels
Exacerbation of NCDs/chronic illnesses	Modest increase in incidence of myocardial infarction, stroke, diabetic foot, worsening control of chronic illnesses like asthma, chronic kidney disease
Injuries –contusions, lacerations, puncture wounds, corneal abrasions, infected wounds, major traumatic injuries	Less data on orthopedic injuries; increase in injuries seen up to 4 weeks after storms. Possible sources of major injuries are: house collapse, uprooted trees, and electrocution

Health Problems	Remarks
Bites and stings – insects, scorpion, snakes, animals	Up to 4 weeks after storms
Acute mental health problems such as acute stress reaction, adjustment disorder, depression, attempted suicide	Begin within 1 week and may persist up to3 months
Post-traumatic stress disorder and other chronic mental health Persist in the long-term 1-5 years after the cyclone	Persist in the long-term 1—5 years after the cyclone
Outbreak of vaccine-preventable diseases in congregate settings	No empirical evidence of increased risk in cyclone settings. However, there is a potential risk of VPD outbreaks if prior vaccine coverage is poor.

Although strong winds are a primary characteristic of cyclonic storms, related phenomena like storm surges and floods are primarily responsible for the destruction to people's lives and property rather than the wind itself. Therefore, those who live in poorly built constructions in low-lying locations close to the coastal areas are most at risk, especially if there is not enough lead time for warning and evacuation. Traumatic injuries and asphyxiation due to entrapment may occur when a cyclone makes landfall because of the collapse of poorly built residential buildings, uprooted trees, and wind-strewn debris. When victims try to secure items like television antennae or boats, they risk electrocution or drowning.

Despite the modest influence of cyclones on infectious diseases, epidemics of illnesses like cholera and leptospirosis are common after storms. Such epidemics are caused by floods and a lack of access to clean water and sanitary services in areas that have recently experienced a hurricane. In addition, epidemics of droplet/airborne illnesses including influenza, measles, and diphtheria are conceivable in crowding places like cyclone shelters, especially if the population impacted by the storm has inadequate prior childhood immunization coverage. The recent pandemic also illustrated the possibility of spreading of Covid-19 in crowded places like cyclone shelters during cyclones.

Although it is a feasible possibility, bringing in medical and paramedical personnel and teams to provide healthcare in cyclone-affected communities is viewed as an improper reaction. Instead, providing emergency medical care to cyclone victims would be best handled by the nearby and local healthcare institutions. The accessibility and provision of healthcare services, however, might be negatively impacted by damage to medical buildings, roads, and electrical power infrastructure.

4.2 Epidemiologic triads to understand cyclone-related health problems

The epidemiologic triangles shown below can be used to explain and comprehend the causes of numerous health issues in post-cyclone environments and situations that promote illness start and dissemination.

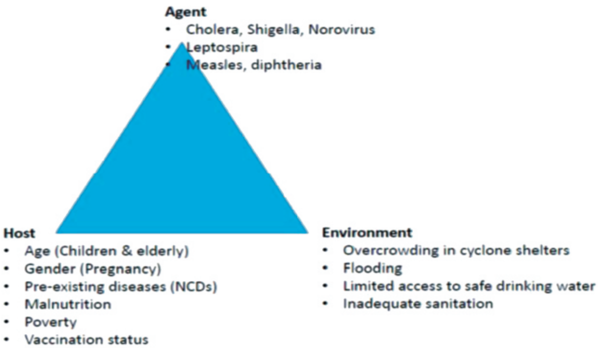

Fig. 4.1 Epidemiologic triad for cyclone-related infectious diseases (Source: NCDC, 2022)

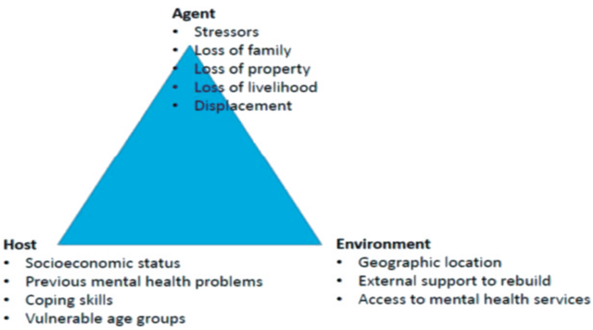

Fig. 4.2 Epidemiologic triad for cyclone-related mental health problems (Source: NCDC, 2022)

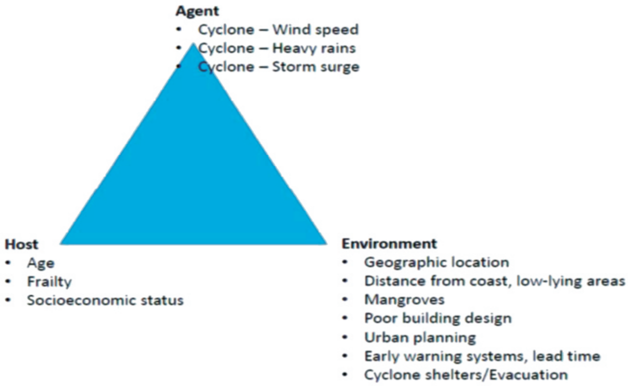

Fig. 4.3 Epidemiologic triad for cyclone-related injuries (Source: NCDC, 2022)

4.3 Action points for State Nodal Officer

Action points for State Nodal Officers can be undertaken within limited resources for measures to control or prevent illnesses (Source: NCDC) as follows:

i) Disaster preparation phase

1. Formulate district specific guidelines with action points and contact name and number of key stakeholders based on previous experience
2. Link with IMD and NDMA for information on disaster impact
3. Assign roles and responsibility of each stakeholder during disaster impact and flow of action
4. Co-ordinate the activities of the stakeholders
5. Train the manpower
6. Supervise and monitor the availability of infrastructure
7. Ensure good information flow between the stakeholders
8. Set up and strength the surveillance system through the IHIP portal
9. Identify the trigger levels during disaster situation for each disease for each PHC and to be incorporated into IHIP portal

10. IEC materials needed during disaster kept ready in collaboration with State IEC department

ii) Response phase

1. Initiate the activities by the health team
2. Co-ordinate the activities of different stakeholders
3. Regulate volunteer action related to health

iii) Recovery phase

1. Strengthen the surveillance to pick up any health event/outbreak
2. Alert and initiate outbreak response based on the reporting through IHIP portal
3. Outbreak investigation in case of outbreak (most outbreak happen at a the recovery phase)
4. Report on the activities done by the health team during disaster and lessons learnt

4.4 COVID-19 compounded disasters

The COVID-19 pandemic, a disaster of unthinkable dimensions and the largest biological shock of the century, is still having an impact on nations all over the world. the pandemic has demonstrated that a disaster risk landscape with more complex, overlapping, and cascading hazards will become the new normal in Asia and the Pacific. It has also shown how inadequately prepared many nations are for complex overlapping crises, despite the fact that some have succeeded in coping with individual disasters, and the biological and natural hazard interactions are still poorly understood.

Climate and pandemic trends should be actively monitored in response to the potential dual difficulties, potential implications of the dual challenge should be evaluated, and early response measures should be put in place. As this is only a preliminary evaluation, it is important to closely watch both the progress of the pandemic and the climate in order to prepare the best course of action as early as possible. India and Bangladesh were both dealing with the escalating COVID-19 illnesses when storm Amphan hit in May 2020. Over 100,000 illnesses have already been reported in India. The reaction and evacuation procedures were made more difficult by lockdowns and travel restrictions. The cyclone also hit low-lying, highly populated coastal districts of West Bengal, Odisha, and neighbouring Bangladesh, where cyclone shelters, community centres, and schools-the customary evacuation centers-had been transformed into quarantine facilities. Numerous of these facilities also housed immigrant populations who had arrived from various cities and states during the lockdown times and were subject to strict quarantine procedures. The difficulty was in shielding the weak from both cyclone Amphan and COVID-19 while they were both inside and outside of emergency shelters.

Sub-Module 5: Cyclone Risk Management and Capacity Development

5.1 Overview

Indian coasts are highly vulnerable to TCs and their associated hazards. The very nature of coast lines, coastal bathymetry and tides, and the socio-economic conditions of the coastal population increase the vulnerability further. Cyclone Risk Management encompasses mitigation and preparedness measures for cyclones.

Table 5.1: Contrasting Cyclone Management Approaches

Rescue and relief centric approach		Holistic DM approach
1. Primary focus on hazards and disaster events	**Emphasis**	Primary focus on vulnerability and risk issues
2. Single, event based scenarios		Dynamic, multiple risk issues and development scenarios
3. Basic responsibility to respond to an event		Fundamental need to asses, monitor and continuously update exposure to changing conditions
4. Often fixed, location specific conditions	**Operations**	4. Extended, changing, shared or regional, local variations
5. Command and control, directed operations		5. Situation-specific functions
6. Established hierarchical relationship		6. Shifting, fluid and tangential relationships
7. Often focused on hardware and equipment		7.Dependent on related practices, abilities and knowledge base
8. Dependent on specialized expertise		8. Specialized expertise, squared with public views and priorities
9. Urgent, immediate and short time frames in outlook, planning, attention, returns	**Time Horizons**	9. In addition to short term measures, moderate and long time frames in outlook, planning and returns

Rescue and relief centric approach		Holistic DM approach
10. Rapidly changing, dynamic information usage, often conflicting or sensitive	**Information use and management**	10. Accumulated, historical, layered, updated, or comparative use of information
11. Primary, authorized or singular information sources, need for definitive facts		11. Open or public information, multiple, diverse or changing sources, differing perspectives, point of view
12. Directed, need to know' basis of information dissemination, availability		12. Multiple use, shared exchange, inter-sectoral use of information
13. Operational/public information based on use of communications		13. Nodal communication

5.2 Preparedness measures

5.2.1 Individual preparedness

NIDM prepared a range of information and advice for preparing for disasters, including how to prepare your emergency plan and prepare your home (https://nidm.gov.in/PDF/IEC/Dosnewnidm.pdf)

5.2.2 Cyclone preparedness tasks and responsibility

S.No.	Task	Responsibility	Activity
1.	National Disaster Management Guideline on Management of cyclones (2008)	NDMA	These guidelines call for a participatory approach involving all stakeholder groups to strengthen the national vision of moving towards a more proactive pre-disaster preparedness and mitigation -centric approach. These contain all the details that are required by planners and implementers and will help in the preparation of plans by the Central Ministries/Departments and the States/UTs.

S.No.	Task	Responsibility	Activity
2.	Cyclone preparedness and response plan	Revenue Dept./ Commissioner of Relief (CoR)	Prepare, test and update State Cyclone P&R Plan periodically.
		SDMAs	Provide guidelines and help to all concern departments to prepare Cyclone P&R Plan.
		All line department	To prepare, test and update department level Cyclone P&R Plan.
3.	Establishment of Cyclone forecasting and warning mechanism	IMD	• Issues daily weather bulletins and weather forecasts. • Issues 4 - Stage warning to State Government, Port Authority, Fisheries Officials and other key depts. in case of cyclone formation.
		Revenue Dept/CoR	• Conduct meetings with the HoDs of line departments before cyclone season to ensure fail -proof cyclone warning and dissemination system and cyclone preparedness measures. • Establish a system of early warning and its dissemination to line departments and others institutions who are likely to be affected by cyclone. • Establish Cyclone warning dissemination centres (If required at the coastal district)
		SDMAs	Analyze the existing early warning and dissemination system, identify gaps and suggest advance system.
4.	Ensure necessary safety measures along the coastal areas	Revenue Dept./CoR	• Review the safety measures taken by concerned dept. before the cyclone season • Establish continuous communication links with IMD, (ACWC and CWC) for further verification of weather condition during the cyclone season

S.No.	Task	Responsibility	Activity
			• Review and monitor an implementation of Coastal Zone Regulation • Make prior arrangements with armed forces so that the people can be rescued in case of cyclone event
		Fisheries dept., Port & Transport dept.	• Fisheries officials should be well equipped Port & Transport and ready for search and rescue of fisherman out of sea during cyclone situation. • Advance planning for getting the help of coast guards in search and rescue operations should be made
		Tourism Dept.	• Visitors/tourist should be informed about cyclone hazard who are visiting vulnerable coastal area during Cyclone season. • Take part in pre-cyclone season meetings • and take all the safety measures recommended by Revenue Dept/CoR.
5.	Review and strengthening relief distribution system and s tock piling	Revenue Dept./CoR, District Collector, Municipal Commissioner, Civil Supply Dept	• Strengthening of relief distribution and accounting system at state and district level • Identification of centralized system for receipt, storage and distribution of relief • Rate contract, procurement and stockpile of relief material
6.	Fail-safe communication and last mile connectivity	Revenue Dept./CoR, SDMAs/DDMAs /Science and Technology Dept./Municipal commissioner	• Undertake study to establish fail safe two way communication-information system from state level to disaster site connecting state, district, taluka and city level • Undertake study to establish alert/siren with multi lingual recorded messages in coastal areas. • Establishment of multiple/alternative system

S.No.	Task	Responsibility	Activity
			• Training/IEC campaign for general public of the vulnerable areas • Plan for re-establishment of disrupted system
7.	Resource Mapping	Revenue Dept./CoR Line dept. Dist. Collectors/SDMAs Other dist. authorities of line Dept.	• Identify available resources viz. Human, financial and equipment for cyclone disaster management with - State Dept. - Dist. Level - Taluka level - Village level - Public sector -Private sector - Community level • Identification of gaps of resources as per the need • Process for procurement of lacking Resources • Periodic up-gradation, validation and maintenance of SDRN[1] and IDRN[2]
8.	Cyclone preparedness, training and capacity building/awareness measures	National Institute of Disaster Management/ SDMAs/DDMAs/ Education Dept. and all line Dept.	• Arrangement for training to: -Trainers from the States/Districts -First Responders (Police, home guard, civil defense, fire & emergency services, medical personnel, port officers, local bodies/PRI) • Advertisement, hording, booklets, leaflets, banners, shake-table, demonstration, folk dancing and music, jokes, street play, exhibition, TV Spot, radio spot, audio-visual and documentary, school campaign, - Planning and Design - Execution and Dissemination

S.No.	Task	Responsibility	Activity
9.	Medical Preparedness	Medical & Health Dept. Commissioner of Health Medical Institutions	• Preparation of authentic medical database for public and private facilities available in the State -Collection of Data - Mapping and Gap analysis -Strengthening • Resource Management -Manpower, logistics, medical equipments, medicines, antidotes, personal protective equipments, disinfectant, vaccine • Identification of medical incident command system - Incident Commander State Level Dist. Level Disaster site • Identification of each section head at each level -Operation -Planning -Logistic -Administration & Finance - Media and Public information Identification of key members of different task force • Control room arrangement - Departmental control room - State and district control room • Planning - Preparation of medical management plan - State level - Dist. Level - Hospital preparedness plan

S.No.	Task	Responsibility	Activity
			• Training and capacity building - Hospital preparedness - Pre hospital care - Mass casualty management etc
10.	Community preparedness	Revenue Dept./CoR/ SDMAs/DDMAs/ IMD/Finance Dept./ DMs/Municipal Commissioners/ Talukadar/local self Govt./Panchayat and Rural Housing Dept	• Selecting vulnerable community and most vulnerable groups at risk • Disseminate information about vulnerability and risk to the community • Promote local level cyclone risk management planning through participatory approach • Advice and issue direction wherever necessary for community cyclone prevention, mitigation and preparedness through local resources and participatory approach • Provide necessary resources and support for cyclone risk reduction at community level • Promote community managed implementations • Review the preparedness at community Level • Take appropriate actions to enhance community preparedness • Promote community education, awareness and training • Ensure fail safe mechanism for timely dissemination of forecasting and warning of impending cyclone to the community • Disseminate information to community to deal with cyclone situation

5.3 Capacity Development

At the national level, The National Institute of Disaster Management (NIDM) is the capacity building arm and the States have disaster management cells in the State Administrative Training Institutes performs the function of capacity building for effective and efficient disaster management. There are a number of other training institutes which are engaged in training and capacity building in the area of disaster management (Described in National Disaster Management Guideline on Cyclone Management, 2008, Page no.118-119).

Odisha example for developing Community Based Disaster Management in India

The eastern state of Odisha in India, situated along the coast of the Bay of Bengal, frequently suffers from cyclones, floods and occasional tsunamis. Hence it has often been referred to as the 'disaster capital' of the country. However, in early August 2020, it was two coastal villages in Odisha, Venkatraipur in Ganjam district and Noliasahi in Jagatsingpur district which earned the recognition of being 'Tsunami Ready' from the UNESCO-Intergovernmental Oceanographic Commission, making India the first country in the Indian Ocean Region to establish such high levels of disaster preparedness at the community level.

Community based disaster risk reduction is at the very heart of Odisha's approach towards disaster management. One of the central themes of the state disaster management plan states that "community-based disaster preparedness is the key to effective disaster management."

(https://www.orfonline.org/expert-speak/following-the-odisha-example-for-developing-community-based-disaster-management-in-india/)

For more details, Read: Community based disaster preparedness- A guide to development workers on Cyclones and floods.

https://www.researchgate.net/publication/275967383_Community_based_disaster_preparedness-_A_guide_to_development_workers_on_Cyclones_and_floods

5.4 Role and Responsibilities

The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

- To develop parameters/guidelines under which NIDM has to function and correspondence relating thereto. Preparation of NIDM guidelines Matters relating to Capacity Building Grant under Finance Commissions.
- International Co-operation including preparation/finalization of MoUs in the field of DM with various countries, and its implementation, visit of foreign delegation for bilateral meetings, etc.
- To coordinate with International Organization such as UNDRR, UNDP, UNICEF, UNOCHA, UNFPA, AHA Centre, IORA, BRICS, SCO, BIMSTEC, ADPC, ADRC, G20, World Bank, SAARC, ASEAN, etc.
- Nomination of officers of NDMA as guest lecturer or participant for attending International and National Workshops / Seminars / Training / Meetings, Forums / etc.
- Implementation of various projects of Capacity Building on Disaster Management (DM), DRR, Disaster Response in collaboration with State Govts/UTs and CDM, LBSNAA, Mussoorie.
- Monitoring of implementation of the National Disaster Management Guidelines on School Safety Policy – 2016 in all schools of India
- Monitoring of DM Exhibition & Mock Drills in all Schools of AMRUT Cities (500).
- Processing of proposals of partial financial support for organizing events on disaster related subjects receives various Departments of GoI/State Govts. and Institutions such as IITs, JNU, FICCI, CII, TIFAC and NGOs etc
- Training part of NDRF

5.5 Standard Operating Procedure (SOP) for effective Cyclone Management

State Governments prepared SOP for effective management of cyclone, taking into account regional specific issues, detailed set of actions with the associated resource requirements and provision for tracking of necessary actions. In light of the Phalin and Hudhud cyclones, NDMA encouraged State Governments to create SOPs by identifying areas to restore pre-disaster circumstances. Some of the SOPs developed by States are shared for refence namely SOP of Anadra Pradesh i.e "Standard Operating Procedures (SOPs) for Cyclone Management based on experiences of "Hudhud" and other Cyclones (http://www.apsdma.ap.gov.in/common_mns/DM_plans/SOP_pdf/2015DM_MS6.pdf)"; "Cyclone Preparedness and response plan" prepared by Gujarat State Disaster management Authority (GSDMA) http://www.gsdma.org/uploads/Assets/other/cyclonepreparedness responseplan06072017051948575.pdf etc.

Sub Module-6 : Pre-Positioning of Resources during Cyclones

6.1 Overview

Cyclones are powerful and destructive natural hazards that can cause significant damage to infrastructure, disrupt essential services, and put human lives at risk. In order to effectively respond to cyclones and minimize their impact, prepositioning of resources plays a vital role. This chapter explores the significance of pre-positioning and the key resources involved, emphasizing the importance of timely actions and coordination to protect lives, safeguard infrastructure, and support affected communities as a strategic preparedness approach.

6.2 Understanding Pre-positioning of Resources

Pre-positioning of resources is a critical strategy employed in disaster management, particularly in the context of cyclones. Cyclone prepositioning refers to the strategic placement of resources, personnel, and equipment in anticipation of a cyclone event. The objective is to enhance disaster preparedness and response capabilities by positioning resources in areas that are likely to be affected by the cyclone. This proactive approach allows for a prompt and coordinated response immediately after the cyclone passes, minimizing the loss of life and property damage. Prepositioning is based on accurate forecasting and prediction models that help identify the areas at highest risk.

6.3 Key Resources for Prepositioning

Some of the key resources commonly prepositioned during cyclones are given below:

- Emergency Response Teams
- Transportation Teams

- Evacuation Centers
- Relief Supplies
- Communication Equipment
- Power Generators
- Heavy Equipment
- Transportation Teams

6.3.1 Emergency Response Teams

Emergency response teams play a vital role in the prepositioning phase of disaster management, particularly during cyclones. Emergency response teams are strategically positioned in high-risk areas before a cyclone to ensure a rapid and coordinated response. These teams include search and rescue personnel, medical professionals, firefighters, and other trained personnel conducting search to provide immediate assistance to the affected individuals. These teams coordinate with local authorities, government agencies, and other stakeholders to ensure efficient collaboration and resource utilization. Emergency response teams are responsible for disseminating timely and accurate information to affected communities, promoting public safety and preparedness. These teams serve as a central point for gathering and analyzing situational data, enabling informed decision-making during the response phase.

6.3.1.1 Search and Rescue Teams

Search and Rescue (SAR) teams are an integral part of emergency response teams during prepositioning efforts. Their primary role is to conduct rapid search and rescue operations, utilizing specialized techniques and equipment to locate and extract individuals in distress. By being prepositioned, SAR teams ensure a quick response, reducing response time and increasing the chances of saving lives. They collaborate with other response teams, provide medical assistance to the rescued, assess damage, and report critical information to the command center.

6.3.1.2 Medical Personnel

Medical personnel, including doctors, nurses, and paramedics, are strategically positioned in high-risk areas to provide immediate medical assistance. By being prepositioned, medical personnel can quickly respond to medical emergencies, injuries, and illnesses caused by the cyclone. They offer vital support in triage, stabilization, and initial treatment of affected individuals. Additionally, they contribute to public health efforts, disease prevention, and the provision of necessary medical supplies and equipment. Their presence during prepositioning ensures that critical medical services are available when they are most needed, ultimately saving lives and mitigating the impact of cyclone-related health risks.

6.3.1.3 Firefighters and Emergency Services

By being prepositioned, firefighters and emergency services personnel can promptly address hazardous situations, conduct evacuations, perform rescue operations, and provide crucial support in maintaining public safety. Their presence ensures a swift and coordinated response, enhancing overall preparedness and reducing the potential risks and damages associated with cyclone events.

6.3.2 Evacuation Centers

The primary role of evacuation centers is to provide safe havens and temporary shelter for individuals who need to evacuate from vulnerable areas. By being prepositioned, evacuation centers ensure that they are adequately equipped with essential supplies such as food, water, bedding, and medical resources. They serve as coordination hubs for response agencies, facilitating efficient operations and information dissemination to evacuees. Moreover, evacuation centers play a critical role in registering and tracking evacuees, ensuring their safety and facilitating their reunification with family members. Their prepositioning allows for timely and organized response, ensuring the well-being and protection of those displaced by the cyclone.

6.3.2.1 Identification and Preparation of Evacuation Centers

The identification and preparation of evacuation centers are crucial steps in the prepositioning of resources during cyclones. This process involves identifying suitable locations in areas prone to cyclone impact and preparing them to serve as safe havens for evacuees. The selection of evacuation centers considers factors such as proximity to at-risk communities, accessibility, structural integrity, and capacity. Preparing these centers involves equipping them with essential supplies, including food, water, medical resources, and bedding. Adequate infrastructure, such as sanitation facilities and security measures, is put in place to ensure the comfort and safety of evacuees. The identification and preparation of evacuation centers in advance enable a swift and efficient response, providing a critical resource for evacuating and protecting vulnerable populations during cyclone events.

6.3.2.2 Essential Supplies for Evacuation Centers

Ensuring the availability of essential supplies is vital for the effective functioning of evacuation centers during prepositioning for cyclones. Some of the essential supplies commonly prepositioned in evacuation centers include food, water, medical resources, bedding, hygiene products, and basic household items. Adequate quantities are stocked to accommodate the expected number of evacuees. Additionally, emergency kits containing first aid supplies, flashlights, batteries, and communication devices should be provided. These supplies are carefully managed, regularly inspected, and replenished as needed to ensure the centers can sustain evacuees for the duration required. Prepositioning essential supplies enables evacuation centers to provide a safe and comfortable environment during cyclone events, promoting the well-being of the evacuees.

6.3.3 Relief Supplies

Prepositioning of relief supplies is of utmost importance to meet the immediate needs of affected communities. These supplies comprise critical resources such as food, water, medicine, shelter, and other essential items required to support affected communities in the aftermath of a cyclone. Prepositioning relief supplies in strategic locations before a cyclone event enables a prompt response, ensuring that aid reaches affected populations as quickly as possible. The relief supplies should be strategically placed in accessible locations to facilitate a timely distribution process.

6.3.3.1 Stockpiling Essential Relief Items

Stockpiling essential relief items is a critical aspect of prepositioning efforts for effective disaster response. Stockpiling involves acquiring, storing, and managing these items in secure warehouses or designated storage facilities in areas prone to cyclone impact. Adequate quantities are maintained to meet the anticipated needs of affected communities. Regular inventory checks, rotation of supplies, and quality control ensure their readiness for deployment. By stockpiling essential relief items, response agencies can quickly respond to cyclone-affected areas, provide immediate assistance, and address the urgent needs of affected populations, enhancing the effectiveness and efficiency of disaster response efforts.

6.3.3.2 Distribution Strategies and Challenges

The effective delivery of the relief supplies involves establishing coordination mechanisms, logistics planning, and the use of various distribution channels. Effective coordination among response agencies, local authorities, and humanitarian organizations is key to ensuring the timely and equitable distribution of relief supplies. Challenges in distribution include access to remote and affected areas, logistical constraints, damaged infrastructure, security risks, and coordinating with diverse stakeholders. Ensuring efficient supply chain management, adapting strategies to local contexts, employing innovative technologies, and conducting regular assessments are essential for overcoming these challenges and ensuring the efficient and equitable distribution of relief supplies to cyclone-affected communities.

6.3.4 *Communication Equipment*

During a cyclone, maintaining communication networks is crucial for effective coordination among response teams and for communication with affected communities. Prepositioning communication equipment such as radios, satellite phones, mobile communication units, and internet connectivity ensure uninterrupted communication in areas where infrastructure may be damaged or disrupted. By prepositioning communication equipment, response teams can establish reliable communication networks, enabling efficient resource allocation, situational awareness, and timely response coordination. It helps enhance overall preparedness, response effectiveness, and the safety of both responders and affected communities during cyclone events

6.3.4.1 Establishing Communication Networks

Establishing communication networks involves setting up robust and reliable communication systems that can withstand potential disruptions caused by the cyclone. Network infrastructure, including towers, antennas, and satellite connections, is strategically positioned in high-risk areas. Additionally, communication equipment such as radios, mobile communication units, and satellite phones are deployed to facilitate communication between response teams, local authorities, and affected communities. These networks ensure timely and accurate information sharing, coordination, and response efforts. By establishing resilient communication networks during prepositioning, emergency responders can effectively communicate, coordinate resources, and provide critical updates to support efficient and coordinated disaster response.

6.3.4.2 Satellite Phones, Two-Way Radios, and Mobile Cell Stations

Satellite phones provide reliable communication capabilities in areas with damaged or non-existent terrestrial infrastructure, ensuring connectivity in remote locations. Two-way radios enable real-time communication between response teams, authorities, and other stakeholders on the ground. They are effective for short-range communication within a localized area. Mobile cell stations, also known as mobile cell towers, can be deployed to restore cellular network coverage in areas where infrastructure has been compromised. These communication equipment options help establish robust and resilient communication networks, enabling effective coordination, information sharing, and response efforts during cyclones when traditional communication systems may be disrupted.

6.3.5 Power Generators

Power outages are common during cyclones, and they can severely hamper emergency response efforts. Prepositioning portable generators and fuel reserves ensures a backup power supply for critical infrastructure, including hospitals, emergency services, and communication systems, enabling them to function even in the event of a power outage.

6.3.5.1 Backup Power Supply for Critical Infrastructure

During cyclones, backup power supply is crucial to ensure continuous electricity in areas where the main power grid may be disrupted. Backup power supply systems, such as generators and battery-powered systems, play a vital role in providing electricity for critical infrastructure, emergency services, and essential facilities. By prepositioning backup power supply equipment in strategic locations, response agencies can quickly restore power and maintain crucial services during and after the cyclone. This ensures that critical operations can continue, emergency communication remains functional, medical equipment operates, and basic needs of affected communities are met, ultimately aiding in the effective response and recovery from the cyclone.

6.3.5.2 Fuel Reserves and Management

Adequate fuel reserves are essential to ensure the continuous operation of generators for an extended period. Response agencies must stockpile sufficient fuel, such as diesel or gasoline, in secure storage facilities near the prepositioned generators. Proper management of fuel reserves involves regular monitoring, rotation, and replenishment to maintain their usability. Additionally, fuel supply chains need to be established to deliver additional fuel as needed during and after the cyclone. Effective fuel management strategies can help ensure the reliability of power generators during cyclones and aid in the effective response and recovery efforts in affected communities.

6.3.6 Heavy Equipment

To aid in the recovery and restoration of essential services post-cyclone, prepositioning heavy equipment is crucial. Specialized machinery and vehicles, such as bulldozers, excavators, cranes, and trucks, are strategically positioned to facilitate efficient response and recovery operations. By prepositioning heavy equipment, response agencies can quickly mobilize resources, enhance operational capacity, and expedite the restoration of critical services and infrastructure, thereby aiding in the effective management and recovery from cyclone events.

6.3.6.1 Role of Heavy Machinery in Recovery Efforts

Heavy machinery including excavators, bulldozers, and cranes, are prepositioned to assist in the restoration of infrastructure, clearing debris, and rebuilding efforts. They are instrumental in removing fallen trees, rubble, and other obstacles, allowing access to affected areas and facilitating the repair of roads, bridges, and buildings. In addition, heavy machinery is necessary for establishing temporary shelters and access routes, especially in hard-to-reach areas. Heavy machinery aids in the efficient and timely reconstruction of critical infrastructure, such as power lines, water supply systems, and communication networks. They are instrumental in conducting search and rescue operations, providing necessary logistical support, and assisting in the distribution of relief supplies.

6.3.6.2 Debris Removal and Infrastructure Repairs

Debris removal involves clearing the debris left behind by the cyclone, such as fallen trees, building materials, and other wreckage. This process is essential to ensure safe access for emergency responders and restore normalcy to the affected community. Heavy machinery, including bulldozers, cranes, and loaders, is utilized to efficiently remove and dispose of debris.

Infrastructure repair focuses on restoring damaged structures, utilities, and transportation networks. This includes repairing roads, bridges, power lines, water and sanitation systems, and communication networks. Skilled workers and specialized equipment are deployed to assess and repair infrastructure, ensuring its functionality and safety.

Both debris removal and infrastructure repair require coordination among various stakeholders, including government agencies, relief organizations, and local communities. Effective planning, resource allocation, and skilled labor are essential for the successful execution of these tasks, facilitating the recovery process and enabling communities to rebuild and regain normalcy following a cyclone.

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6.3.7 Transportation

The prepositioning of transport facilities during cyclones plays a crucial role in disaster preparedness and response. It involves strategically placing and arranging transportation resources in vulnerable areas before a cyclone strikes to ensure swift and effective evacuation, rescue operations, and the delivery of essential supplies. Here are some key roles and benefits of prepositioning transport facilities during cyclones:

6.3.7.1 Evacuation: Prepositioning transport facilities allows for the rapid evacuation of people from high-risk areas before a cyclone makes landfall. This includes arranging buses, boats, helicopters, or other means of transportation to move people to safer locations such as shelters or evacuation centers. Timely evacuation can save lives and reduce the impact of a cyclone on the affected population.

6.3.7.2 Rescue Operations: During and after a cyclone, prepositioned transport facilities enable quick response and rescue operations. This includes positioning rescue teams, search and rescue vehicles, boats, and helicopters in areas likely to be affected by the cyclone. These resources can swiftly reach affected communities, provide medical assistance, and rescue individuals stranded by floods or other cyclone-related hazards.

6.3.7.3 Supply Delivery: Cyclones often disrupt regular supply chains, making it challenging to deliver essential items such as food, water, medical supplies, and equipment to affected areas. Prepositioning transport facilities allows for the rapid delivery of these supplies to ensure that affected communities have access to necessary resources. This can be achieved by positioning trucks, aircraft, or ships with emergency supplies in nearby safe locations.

6.3.7.4 Post-cyclone Recovery: After a cyclone passes, prepositioned transport facilities are vital for conducting post-disaster assessments, distributing relief materials, and supporting recovery efforts. These facilities enable efficient access to affected areas, allowing relief workers, government agencies, and humanitarian organizations to evaluate damage, plan reconstruction, and deliver aid effectively.

6.3.7.5 Coordination and Logistics: Prepositioning transport facilities enhances coordination and logistics planning among various stakeholders involved in cyclone response. It allows authorities to strategically allocate resources, ensure effective communication networks, and streamline transportation operations. This coordination ensures a more organized and timely response, minimizing chaos and improving overall disaster management.

Prepositioning transport facilities during cyclones facilitates timely evacuation, efficient rescue operations, and the delivery of essential supplies, contributing to saving lives and promoting swift recovery in the aftermath of a cyclone.

6.4 Use of Advanced Technology in Resource Identification

By leveraging advanced technology, response agencies can improve their situational awareness, enhance decision-making processes, optimize resource allocation, and effectively preposition resources to mitigate the impact of cyclones and save lives.

India Disaster Resource Network:

IDRN is a web-based platform enables decision-makers to access this inventory, ensuring efficient resource allocation during disasters developed by National Institute of Disaster Management in India. The IDRN collates information from districts, states, and national level agencies to create a web-based platform accessible to decision makers. API modules have been developed to share IDRN data with state government applications and are currently used in five states i.e. viz. Kerala, Bihar, Jammu & Kashmir, Ladakh, Himachal Pradesh. The development of an IDRN mobile application is also under consideration. The use of advanced technology, such as the IDRN, helps ensure that resources are readily available and effectively distributed during emergency response efforts.

Prepositioning of resources during cyclones is a proactive approach that significantly enhances disaster preparedness and response capabilities. By strategically placing emergency response teams, evacuation centers, relief supplies, communication equipment, power generators, and heavy machinery, authorities can minimize response time, save lives, and facilitate the recovery process. However, effective prepositioning requires accurate forecasting, robust coordination among agencies, and continuous evaluation and improvement of preparedness plans. By prioritizing prepositioning efforts, communities and authorities can better withstand the destructive force of cyclones and mitigate their impact on both human lives and infrastructure.

Reference:

IDRN -NIDM accessed at https://idrn.nidm.gov.in/

Sub Module 7: Cyclone Risk Mitigation

7.1 Overview

Recurrent cyclones account for large scale deaths, loss of livelihood opportunities, loss of public and private property, and severe damage to infrastructure. To reduce the loss of life and properties in the events of future calamities, Government of India has taken several initiatives.

An important aspect of cyclone risk reduction is to ensure availability of adequate numbers of shelters, community centres/school buildings, places of worship, etc., which can be utilized for moving people from vulnerable areas to safety. Besides this, the structural safety of various lifeline infrastructure such as roads/culverts/bridges, communication and transmission towers, power houses, water towers and hospitals will be ensured, so that the communication system at all levels remains useable, the electricity and water supply systems do not break down and adequate medical attention is possible.

It has been identified that design and maintenance considerations are the main focal points to be addressed which would improve the cyclone preparedness. This will cover:

(i) Buildings, including multi-purpose cyclone shelters;

(ii) Road links, culverts and bridges;

(iii) Canals, drains, and surface water tanks, etc.;

(iv) Saline embankments; and

(v) Communication towers and power transmission networks.

7.2 Mitigation Measures

The mitigation measures as proposed by the UN-HABITAT are given below:

1. **Hazard Mapping–** It suggests that using hazard mapping, one can predict the vulnerable areas affected by the storms. It maps the pattern of old cyclones using their wind speed, areas affected, flooding frequency etc.
2. **Land use planning–** With the effective implementation of land use planning, the key activities and settlements can be avoided in the most vulnerable areas. For example, a settlement in the floodplains is at utmost risk. Hence, authorities should plan ahead to avoid such risks.
3. **Engineered Structures–** These structures withstand the wind forces and prove to mitigate the losses. The public infrastructure of the country should be designed keeping in mind the hazard mapping of the cyclone.
4. **Retrofitting Non-Engineered Structures–** The settlements in non-engineered structures should ensure that they are aware of their houses' resistance to the wind or certain disastrous weather conditions. A few examples of retrofitting the non-engineered structures given by UN-HABITAT are:
   - Construction of a steep-slope roof to avoid the risk of being blown away.
   - Anchoring strong posts with solid footings on the ground.
   - Plantations of trees at a safe distance from the house to help break the wind forces.
   - Repair of the shelters before time.
5. **Cyclone Sheltering–** At national, state and regional level, the construction of cyclone shelters should be taken up to help the vulnerable community from cyclones. The shelters should be built considering the population density, transportation and communication, distance from the affected areas of the past, and the areas' topography. Guidelines for Design and Construction of Cyclone/Tsunami Shelters are available on the NIDM website. (https://nidm.gov.in/PDF/safety/public/link3.pdf) and the cyclone shelters management guidelines are developed by United Nations Centre for Regional Development (UNCRD) and Swiss Agency for

Development and Cooperation (SDC) (https://www.uncrd.or.jp/content/documents/Sheltermanagement_english.pdf).

6. **Flood Management–** As the cyclonic storms lead to heavy rainfall that further lead to flooding in various areas; important should be given to the flood management. The drainage systems should be well-designed to mitigate flooding. The participation both from the government and the local community is required for this.

7. **Vegetation Cover Improvement–** To increase the water infiltration capacity, improving vegetation cover is of high importance. Planting trees in rows, coastal shelterbelt plantations, mangrove shelterbelt plantations, etc can help break the wind force and mitigate the severe losses.

8. **Mangrove Plantation–** The ecologically-efficient mangroves should be planted more. India has 3 per cent of the world's mangroves cover. The root systems of mangroves help in mitigating tsunamis, soil erosion etc.

9. **Saline Embankment–** Along the coast, saline embankments help protect habitation, agricultural crops, and other important installations.

10. **Levees–** They act as an obstruction to the wind forces and also provide a shelter during floods.

11. **Artificial Hills–** These act as the refuge during flooding, and should be taken up in the right areas.

12. **Awareness of the public–** The participation of the community increases with the number of public awareness initiatives. The governments at all levels should initiate programs bringing awareness about the natural calamities and making provisions for higher local participation in the mitigation process.

7.3 Governmental Initiatives for Cyclone Management in India

Mitigation Funds

Under the Disaster management Act 2005; Section 47(1): The Central

Government may, by notification in the Official Gazette, constitute a Fund to be called the National Disaster Mitigation Fund (NDMF) for projects exclusively for the purpose of Mitigation and there shall be credited thereto such amount which the Central Government may, after due appropriation made by Parliament in this behalf, provide. Similarly, the DM Act (2005), Section 48 (1) of Chapter IX directs the State Governments to establish State Disaster Mitigation Fund (SDMF) on such mitigation activities that are not covered under any of the existing plan schemes. The provision for relief, rehabilitation and reconstruction should not be a part of State Disaster Mitigation Fund.

NDMF/ SDMF will be applied by NDMA/ SDMA for appraisal, monitoring and supervision of mitigation projects.

Government Housing Programmes

Pradhan Mantri Awas Yojana - Urban (PMAY-U) by the Ministry of Rural Development and under the Jawaharlal Nehru National Urban Renewal Mission (JNNRUM) of the Ministry of Urban Affairs are taken up by the central government. Several government programmes are also taken up by the states/UTs as well. They will ensure that cyclone-resistant features are incorporated in their planning and execution. All government housing programmes (including selection of site) will get clearance from the competent authority, which will take into account all prescribed DM norms pertaining to selection of sites, layout and all other issues. Housing schemes of local governments will get clearance—which will include selection of site- from the local DM department.

National Cyclone Risk Mitigation Project (NCRMP)

National Cyclone Risk Mitigation Project (NCRMP) is a World Bank assisted flagship programme (https://projects.worldbank.org/en/projects-operations/project-detail/P144726) being implemented by NDMA in 8 cyclone prone coastal states in two phases i.e. phase I (January 2011- December 2018) and phase II (July 2015- March 2020) with the following components:

- Component A: Early Warning Dissemination System (EWDS)

- Component B: Cyclone Risk Mitigation Infrastructure (CRMI)
- Component C: Technical Assistance for Capacity Building on Disaster Risk Management
- Component D: Project Management and Monitoring

Integrated Coastal Zone Management (ICZM) Project

- The Ministry of Environment, Forest and Climate Change (MoEFCC) has unveiled the draft Environmental and Social Management Framework (ESMF) for Integrated coastal management.
- The draft plan will dictate how prospective infrastructure projects would be assessed for clearance by laying out guidelines for coastal States.

Coastal Regulation Zones (CRZ)

The coastal areas of seas, bays, creeks, rivers, and backwaters which get influenced by tides up to 500 m from the high tide line (HTL) and the land between the low tide line (LTL) and the high tide line have been declared as coastal regulation zone (CRZ) in 1991.

- The coastal regulation zones have been declared by the Ministry of Environment, Forest and Climate change under the Environment Protection Act 1986.

Color Coding of Cyclones

- It is a weather warning that is issued by the India Meteorological Department (IMD) to alert people ahead of natural hazards.
- The four colors used by IMD are Green, Yellow, Orange, and Red.

Sub Module 8: Technology and Emerging Trends

8.1 Introduction

Technology has the potential to revolutionize disaster management, particularly if it is properly incorporated with existing infrastructure. As cutting-edge technologies like artificial intelligence (AI), the internet of things (IoT), big data, and blockchain become even more sophisticated, they can significantly boost India's disaster response and assistance capacity. When strong concepts and cutting-edge equipment come together, new developments in catastrophe management are made.

The following technologies find applications in disaster management:

I. Big Data

The amount of information created has increased at a phenomenal rate as a result of rapid digitization and the widespread use of smartphones across all demographics. When this data is carefully processed, it has the potential to reveal significant insights. Big Data analytics has risen in popularity as a result of this possibility.

II. Artificial Intelligence

This is relevant to disaster management as well. During and after a crisis, it can be helpful to follow people's movements and administer aid efficiently by keeping an eye on data like social media conversations, financial transactions, and mobile phone activities. Predictive analytics may utilise AI-based algorithms to foresee disasters and speed up recovery and reaction times. The identification of damaged roads, buildings, and other features can be made possible using AI-powered picture recognition. By fusing several data sources, it may also create heat maps.

The large call volumes to emergency hotlines can also be handled by AI-based chatbots or voice response systems to produce more efficient results.

III. Internet of Things

A complex system known as the Internet of Things has emerged because to the development of cloud computing technologies and internet (IoT). By monitoring carbon dioxide levels, moisture content, and temperature, IoT-based sensors can assist identify potentially harmful circumstances, detect tectonic changes, and identify forest fires. Additionally, they can make it possible to monitor river levels to spot flooding.

IV. Robotics

Robots are incredibly sophisticated today because to advancements in computer technology and are able to better support and complement human performers or save animals. These may be incredibly helpful for NDRF units, particularly in difficult terrain and dangerous operational settings. Robots may be able to assist in saving the lives of victims without jeopardising the lives of rescuers.

V. Blockchain

Organizations typically struggle to ensure resources are used for the intended reasons during relief operations due to a lack of trust, openness, and measurability. Misinformation in these situations frequently threatens the safety and can lead attempts to fail.

These worries can be lessened by blockchain technology, which also makes it possible to gather and handle trustworthy data quickly. Automated decision-making in disaster-prone contexts is possible thanks to smart contracting systems that take use of the improved dependability of data that has been encoded on a blockchain. This can speed up judgments and release some of the tension on the rescuers. The potential for developing comprehensive disaster management systems in India with the use of this cutting-edge technology is enormous. India may serve as an example of the best disaster management practices for the entire globe with increased investment in cutting-edge technology.

VI. Machine Learning

Machine learning can provide new ways of looking into the complex relationships between models, and the actual understanding of the potential impacts of a hazard on the built environment and society. It aims to provide more accurate, efficient, and useful answers.

Evidence-driven disaster risk management (DRM) relies upon many different data types, information sources, and types of models to be effective. Tasks such as weather modelling, earthquake fault line rupture or the development of dynamic urban exposure measures involve complex science and large amounts of data from a range of sources. Even experts can struggle to develop models that enable the understanding of the potential impacts of a hazard on the built environment and society.

8.2 Community Radio / Amateur Radio

Ham radio and community radio plays a tremendous role during natural disasters such as cyclones, floods, landslides, tsunami, earthquakes etc. However, the level of awareness of these radio communications in India is still low. Volunteers from community radio and amateur radio can become frontline reporters in a disaster emergency. Persons involved in media such as community radio have a close relationship with the community and understand the local existing environmental conditions and the reality faced by victims better than journalists from the mainstream media.

India's zero casualty approach to managing extreme weather events is a major contribution to the implementation of the Sendai framework and the reduction of loss of life from such events. India's Zero Casualty Policy refers to Indian Meteorological Department's “almost pinpoint accuracy” of early warnings that helped authorities conduct a well-targeted evacuation plan and minimise the loss of life against extremely severe cyclonic storm Fani.

Early warning and communication plays a crucial role in disaster management by disseminating information about the disasters, educating public about disaster, highlighting vulnerable zones, spreading warning and alert, reporting of disaster events, gathering and transmitting informatifon about affected areas, assisting in rescue and relief operations, disseminating information about public safety, informing and alerting the concern authorities and government officials, assisting volunteers, relief organizations etc. The continuous and factual coverage of disaster event by media immediately after a disaster aids response and decision making activities, thereby saving lives and property.

There are many examples where public education and the rapid, widespread dissemination of early warnings saved thousands of lives. The 1977 cyclone in Andra Pradesh, India killed more than 10,000 people, while a similar storm in the same area 13 years later killed only about 910. The dramatic difference - was due to the fact that a new early-warning system connected with radio stations to alert people in low-lying areas, was put into place (R. K. Dave, www.training.fema.gov).

Uttarakhand witnessed a multi-day cloudburst on June 2013 leading to devastating flash floods and landslides where as on 09 May 2014, a total of 169 people died and 4021 people were reported missing (presumed to be dead) (Satendra et. al 2014). It became the country's worst natural disaster since the 2004 tsunami. Community radios were among the first responders and were involved in broadcasting and sensitizing vital information to victims and response teams. At several community stations, Gram Vaani established operating Relief News lines for Uttarakhand flood victims to provide help with three community radios namely Kumaon Vani (Mukteshwar), Henvalvani (Chamba Valley) and Mandakini Ki Awaz (Rudraprayag).

The 2004 Great Sumatra earthquake and the Indian Ocean tsunami, also known as Boxing Day Tsunami, occurred on 26th December 2004, with a magnitude of 9.3 Mw, causing extensive damage to Andaman and Nicobar Islands (UT) and mainland coast in the states of Kerala, Tamilnadu. The tsunami was considered as one of the deadliest natural hazards in the history, killing over 230,000 people in fourteen countries. In India it claimed 10,745 lives according to official estimates (INCOIS, Indian Tsunami Early Warning Centre User Guide). In the immediate aftermath of the disaster, Ham radio, Community radio, Immersat and VSAT phones were used to assist in relief and rescue operations. Community media is often considered a medium of broadcasting that gives voice to the voiceless and brings into limelight the issues and problems faced by the affected community. Though the concept of community radio is decades old, it is still in a nascent stage and also needs support from the district, state and central level to develop, grow and become an integral part of disaster management.

The 1999 Odisha cyclone was the most intense recorded tropical cyclone in the North Indian Ocean (NIO) and among the most destructive in the region. The cyclone resulted in over 10,000 deaths fatalities (ww.ndma.gov.in) and total damage cost amounted to US 4.44 billion dollars. Throughout the storm's lifetime, Indian Meteorological Department (IMD) periodically issued cyclone warning bulletins. Hourly dissemination of cyclone bulletins was carried out by Doordarshan and All India Radio to affected areas which have greatly reduced the number of death.

8.3 Social Media in Disaster Management

The media forges a direct link between the public and emergency organizations and plays a very important role in disseminating vital information to the public before, during and after disasters. The media assists in the management of disasters by educating the public about disasters; warning of hazards; gathering and transmitting information about affected areas; alerting government officials, relief organizations and the public to specific needs; and facilitating discussions about disaster preparedness and response for continuous improvement.

Information is the most valuable commodity during emergencies or disasters. It is what everyone needs to make decisions. It is an essential aspect in an organization's ability to gain (or lose) visibility and credibility. Above all, it is necessary for rapid and effective assistance for those affected by a disaster. Information is the main element in the damage and needs assessment process and is the basis for coordination and decision making in emergency situations. It has a powerful impact on how national and international resources are mobilized.

Public and social communication and media relations have become key elements in efficient emergency management. Technical operations in disaster situations must be accompanied by good public communication and information strategies that take all stakeholders into account.

Over the last decade, there has been an overwhelming amount of cases where false news spreads during crisis events, such as natural disasters and terrorist attacks. This misinformation proves to be very dangerous during these menacing situations, as the integrity and accuracy of emergency communications is of the utmost importance. Given that emergency communications are often needed for affected populations to make informed decisions regarding planning and evacuation, it is vital that misinformation is controlled in an effective and efficient manner. The threat of misinformation propagating throughout social media brings the need for timely and valid debunking posts from trustworthy accounts. In many of the cases where false information spreads during disaster events, government accounts and other major accounts turn to social media to supply the public with updated information (NDMA, 2012).

8.4 CAP-Integrated Alert System

Common Alerting Protocol (CAP) is widely used for exchanging public warnings and emergencies between alerting technologies. CAP facilities simultaneous dissemination of warning message over many warning systems to many applications such as Cell Broadcast, Google Public Alerts etc. This technique simplifies the task and enhances the effectiveness of warning dissemination to responsible officials.

CAP has several characteristics such as flexible targeting specific geographic areas, message in multilingual and multi-audience, phased and delayed effective times and expirations, enhanced message update and cancellation features, template support for framing complete and effective warning messages, digital encryption and signature capability, facility for digital images, audio, and video etc.

India's Common Alert Protocol is conceptualized by NDMA based on Globally accepted Common Alerting Protocol. It facilitates MHA and all State/UT government to disseminate location-based disaster alerts to citizens in vernacular languages in near real time for enabling people to act timely and reduce the possibility of harm, loss or risk. It integrates Alert Generating Agencies like IMD, CWC, INCOIS, DGRE formerly (SASE) on a National level common platform. An MoU was signed between NDMA and CDOT on 23rd August 2021 for Pan India's implementation of the CAP Project.

8.4.1 Purpose of CAP-Integrated Alert System

The purpose of CAP- integrated alert system are as follows:

- Globally accepted ITU-T x.1303 CAP standard-based system for disaster alert information exchange
- Integration of all Agencies under one umbrella saving the precious time used in communication
- Ensures Last mile Reachability to the Citizens using all possible Dissemination methods for Any Hazard, To anyone
- Also covers the seasonal or tourist population of the area to be affected
- Geo-targeted warning, increase effectiveness and sanctity as Information reaching only to the targeted public
- Vernacular languages Support to ensure understandability among the local population
- Impact based Alerting to send different alert messages in different parts of the affected area
- Using Satellite Communication to cover area where terrestrial communication is not available or is disrupted
- Multilevel Secure authentication and Trusted Device Mechanism to prevent any unauthorized access
- Supports different voice notification tone to cater to visually impaired persons and for addressing odd hours.

8.4.2 Working of CAP-Integrated Alert System

The detailed working of CAP-Integrated alert system is represented via graphical representation in figure below.

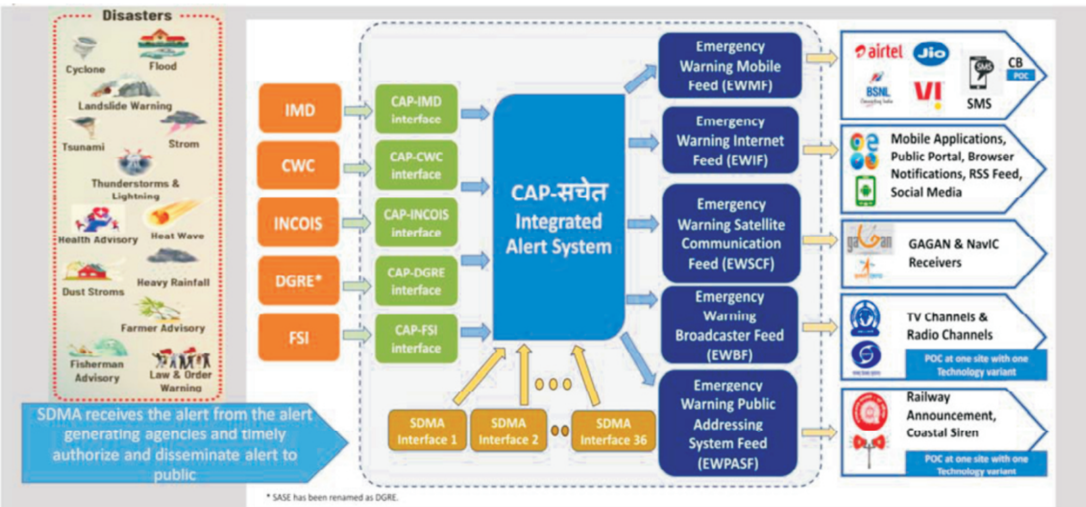

Fig. 8.1 Working of CAP-Integrated Alert System

8.4.3 Possible Use case scenarios of CAP-Integrated Alert System

Some of the key points in CAP-Integrated Alert System are as follows:

- Location Based SMS to disseminate Geo targeted Alerts.
- Location specific Regular weather warnings and advisories through Mobile App.
- Advisories to fishermen in sea where other type of communication is not possible through NavIC and GAGAN .
- Evacuation plan and safe places related information sharing over all media.

CAP-Integrated Alert System can be implemented in pre-disaster, during disaster and post disaster scenarios for various purposes as follows:

a) Pre-disaster

- Flood Alerts
- Cyclone alerts
- Avalanche alerts
- Tsunami alerts
- Lightning/ Thunderstorm related advisories
- Fishermen Advisories
- Helpline nos.
- Shelter/ Evacuation Instruction

b) During the Disaster

- Alert updates
- Information about safe places
- Do's and Don'ts
- Helpline nos.

c) Post-Disaster

- Relief related info
- Landslides location
- Earthquake rescue and relief ops
- Helpline nos.

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About the Institute

National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the establishment of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

NIDM is proud to have a multi-disciplinary core team of professionals working in various aspects of disaster management. In its endeavour to facilitate training and capacity development, the Institute has state-of-the-art facilities like class rooms, seminar hall and video-conferencing facilities etc. The Institute has a well-stocked library exclusively on the theme of disaster management and mitigation. The Institute provides training in face-to-face, on-line and self-learning mode as well as satellite based training. In-house and off-campus face-to-face training to the officials of the state governments is provided free of charge including modest boarding and lodging facilities.

NIDM provides Capacity Building support to various National and State level agencies in the field of Disaster Management & Disaster Risk Reduction. The Institute's vision is to create a Disaster Resilient India by building the capacity at all levels for disaster prevention and preparedness.

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