

# National Disaster Management Guidelines

## Management of Cyclones



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National Disaster Management Authority  
Government of India



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Vice Chairman  
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## **FOREWORD**

India has a coastline of 7,516 km, of which 5,700 km are prone to cyclones of various degrees. About eight per cent of the Country's area and one-third of its population live in 13 coastal states and UTs who are, thus vulnerable to cyclone related disasters. Loss of lives, livelihood opportunities, damage to public and private property and severe damage to infrastructure are the resultant consequences, which can disrupt the process of development. Climate change and the resultant sea-level rise is also likely to exacerbate the seriousness of this problem in the coming decades.

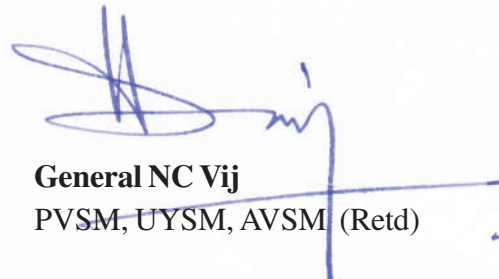
The National Guidelines for the Management of Cyclones have been formulated after a 'nine step' process taking on board completely, various Central Ministries, Departments, States and UTs. The process also included wide consultations with scientific and technical institutions, academics, technocrats and humanitarian organisations. The draft guidelines document was circulated to all the Ministries/ Departments at the Centre and the States and UTs for their feedback. All workable suggestions have been incorporated.

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.

A National Cyclone Risk Mitigation Project of approximately Rs. 1,600 crore, with assistance from the World Bank, is in the process of finalization, covering all the 13 coastal States/UTs. The various activities under this project will include construction of cyclone shelters, shelter belt/mangrove plantations, establishing last mile connectivity, improving link roads, etc. Once all the activities, as laid down in these guidelines are implemented, we will be much better prepared to face the hazards of cyclones.

I am grateful to the members of the core group and coordinators and members of different sub-groups who contributed to this effort. Finally, I am pleased to place on record my sincere appreciation for Shri M. Shashidhar Reddy, MLA, Member, NDMA, who guided and coordinated the entire exercise.

New Delhi  
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**M. Shashidhar Reddy, MLA**

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# Abbreviations

ACTS	Advanced Computational Testing and Simulation
ACWC	Area Cyclone Warning Centre
AFS	Area Forecast System
AICTE	All India Council for Technical Education
AIR	All India Radio
AM	Amplitude Modulation
AMSU	Advance Microwave Sounding Unit
APC	Aircraft Probing of Cyclone facility
APC <sup>1</sup>	Areas of Particular Concern
APHM & ECRP	Andhra Pradesh Hazard Mitigation and Emergency Cyclone Recovery Project
APSDMS	Andhra Pradesh State Disaster Mitigation Society
ARC	Armoured Reconnaissance Aircraft
ASSOCHAM	Associated Chambers of Commerce and Industry
ATI	Administrative Training Institute
BARC	Bhabha Atomic Research Centre
BIS	Bureau of Indian Standards
Bn	Battalion
BOO	Build Operate Own
BOOT	Build Operate Own Transfer
BSI	Botanical Survey of India
BSNL	Bharat Sanchar Nigam Limited
CBDM	Community Based Disaster Management
CBO	Community Based Organization
CBRN	Chemical, Biological, Radiological and Nuclear Agencies
CCMNC	Cabinet Committee on Management of Natural Calamities
CCS	Cabinet Committee on Security
CDM	Cyclone Disaster Management
CDMA	Code Division Multiple Access
CDMC	Cyclone Distress Mitigation Committee
CDMIS	Cyclone Disaster Management Information System
CDT	Civil Defence Teams
CERP	Cyclone Emergency Reconstruction Project
CESS	Centre for Earth Science Studies
CEWS	Cyclone Early Warning System
CGWA	Central Ground Water Authority

CGWB	Central Ground Water Board
CIDS	Chief of the Integrated Defence Staff
CII	Confederation of Indian Industry
CMC	Crisis Management Committee
CMG	Crisis Management Group
CoS	Committee of Secretaries
CPAP	Continuous Positive Air Pressure
CPDAC	Coastal Protection & Development Advisory Committee
CRC	Cyclone Review Committee
CRF	Calamity Relief Fund
CRMI	Cyclone Risk Mitigation Investments
CRZ	Coastal Regulation Zone
CSC	Common Services Centre
CSIR	Council of Scientific and Industrial Research
CSO	Central Statistical Organisation
CSS	Common Service Scheme
CWC	Central Water Commission
CWC <sup>1</sup>	Cyclone Warning Centre
CWDS	Cyclone Warning Dissemination System
CZM	Coastal Zone Management
DAMA	Demand Assigned Multiple Access
DBT	Department of Biotechnology
DCWDS	Digital Cyclone Warning Dissemination System
DDA	Digital Data Adaptor
DDC	Data Distribution Centre
DDMA	District Disaster Mitigation Authorities
DEM	Digital Elevation Model
DEOC	District Emergency Operations Centre
DES	Directorate of Economics and Statistics
DIT	Department of Information Technology
DM	Disaster Management
DMIS	Disaster Management Information System
DMP	Disaster Management Plan
DMU	Disaster Management Unit
DoE	Department of Environment
DOS	Data Oriented Service
DoS	Department of Space
DoT	Department of Telecommunications
DPAD	Data Processing and Application Development

## ABBREVIATIONS

DRC	Data Radio Channel
DRDO	Defence Research and Development Organisation
DRM	Disaster Risk Management
DRMP	Disaster Risk Management Programme
DSS	Decision Support Systems
DST	Department of Science & Technology
DTH	Direct-To-Home
DVB	Digital Video Broadcasts
DVB-RCS	Digital Video Broadcast with Return Carrier through Satellite
DVC	Data Validation Centre
DWR	Doppler Weather Radar
DWS	Disaster Warning System
ECMWF	European Centre for Medium-Range Weather Forecasting
EEP	Emergency Evacuation Plan
EEZ	Exclusive Economic Zones
EGIA	Ecologically and Geomorphologically Important Areas
EIA	Environment Impact Assessment
EPA	Environmental Protection Act, 1986
EPZ	Export Processing Zone
ER	Emergency Response
ERP	Emergency Response Platform
ESCAP	United Nations Economic and Social Commission for Asia & Pacific
ESS	Earth and Space Science
EW	Early Warning
EWER	Early Warning Emergency Response
EWS	Early Warning System
FICCI	Federation of Indian Chambers of Commerce and Industry
FM	Frequency Modulation
FSI	Forest Survey of India
FTDMA	Frequency Time Division Multiple Access
GIS	Geographical Information System
GPRS	General Packet Radio Service
GoI	Government of India
GPS	Global Positioning System
GSDMA	Gujarat State Disaster Management Authority
GSDP	Gross State Domestic Product
GSI	Geological Survey of India
GSM	Global System for Mobile Communications
GTS	Global Telecommunication System

GWB	Ground Water Board
HDSS	Hazard Decision Support System
HFL	High Flood Level
HHZ	High Hazard Zone
HLCC	High Level Cabinet Committee
HLT	Hurricane Liaison Team
HPC	High Powered Committee
IAF	Indian Air Force
IAY	Indira Awas Yojana
ICAR	Indian Council of Agricultural Research
ICMAM	Integrated Coastal Area & Marine Management
ICRC	International Committee on Red Cross
ICS	Incident Command System
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IDKN	India Disaster Knowledge Network
IDNDR	International Decade of Natural Disaster Reduction
IDRN	India Disaster Resource Network
IGNOU	Indira Gandhi National Open University
IIT	Indian Institute of Technology
IMD	India Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
INMARSAT	International Maritime Satellite
IOC	Integrated Operation Centre
IRC	Indian Red Cross
ISDN	Integrated Service Digital Network
ISRO	Indian Space Research Organisation
JFM	Joint Forest Management
JMA	Japan Meteorological Agency
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
JTWC	Joint Typhoon Warning Centre
LAN	Local Area Network
LBSNAA	Lal Bahadur Shastri National Academy of Administration
LHZ	Low Hazard Zone
LMC	Last Mile Connectivity
LRB	Low-Rise Buildings
MAN	Metropolitan Area Network
MAP	Management Action Plan
MCS	Meso-scale Convective System

## ABBREVIATIONS

MDD	Meteorological Data Distribution
MFTDMA	Multi-Frequency Time Division Multiple Access
MHA	Ministry of Home Affairs
MHRD	Ministry of Human Resource Development
MMP	Mission Mode Projects
MoA	Ministry of Agriculture
MoEF	Ministry of Environment and Forests
MoES	Ministry of Earth Sciences
MoHFW	Ministry of Health & Family Welfare
MoI&B	Ministry of Information and Broadcasting
MoIT	Ministry of Information Technology
MoRD	Ministry of Rural Development
MoUD & PA	Ministry of Urban Development and Poverty Alleviation
MoWR	Ministry of Water Resources
MPCS	Multipurpose Cyclone Shelters
MSSRF	M.S. Swaminathan Research Foundation
MTN	Main Telecommunication Network
MTNL	Mahanagar Telephone Nigam Limited
MW	Medium Wave
NABARD	National Bank for Agriculture and Rural Development
NAP	National Afforestation Programme
NASA	National Aeronautical and Space Administration
NATMO	National Thematic Mapping Organization
NBSSLUP	National Bureau of Soil Survey and Land-Use Planning
NCC	National Cadet Corps
NCCF	National Calamity Contingency Fund
NCDMI	National Cyclone Disaster Management Institute
NCEP	National Centre for Environmental Prediction
NCERT	National Council of Educational Research and Training
NCMC	National Crisis Management Committee
NCMRWF	National Centre for Medium Range Weather Forecasting
NCPP	National Coastal Protection Project
NCRMf	National Cyclone Risk Management Facility
NCRMP	National Cyclone Risk Mitigation Project
NCST	National Committee of Science & Technology
NCZP	National Coastal Zone Policy
NDCI	National Disaster Communication Infrastructure
NDEM	National Database for Emergency Management
NDM	National Disaster Management



NDMA	National Disaster Management Authority
NDMR	National Disaster Mitigation Reserve
NDMRC	National Disaster Mitigation Resource Centre
NDRF	National Disaster Response Force
NEC	National Executive Committee
NeGP	National e-Governance Plan
NEP	National Environment Policy
NHC	National Hurricane Centre
NHMIS	Natural Hazards Management Informatics Program of NIC
NHO	Naval Hydrographic Office
NIC	National Informatics Centre
NIDM	National Institute of Disaster Management
NIO	North Indian Ocean
NIOT	National Institute of Ocean Technology
NIRD	National Institute of Rural Development
NISA	National Industrial Security Academy
NMS	Network Management Software
NMTN	National Meteorological Telecommunication Network
NRSA	National Remote Sensing Agency
NSDI	National Spatial Data Infrastructure
NSS	National Service Scheme
NSSO	National Sample Survey Organisation
NTRO	National Thematic Research Organisation
NFVM	National Forest Vegetation Map
NWP	Numerical Weather Prediction
NWSTG	National Weather Service Telecommunications Gateway
NYKS	Nehru Yuvak Kendra Sangathan
OC	Operations Centre
OSDMA	Orissa State Disaster Mitigation Authority
PAD	Programme Associated Data
PAS	Public Address System
PMSS	Probable Maximum Storm Surge
PPP	Public-Private Partnership
PRI	Panchayati Raj Institution
PSDN	Public Switched Data Network
PSTN	Public Switched Telephone Network
PVA	Participatory Vulnerability Assessment
RF	Radio Frequency
RMP	Resource Management Plan

## ABBREVIATIONS

RMTN	Regional Meteorological Telecommunication Network
RRC	Regional Response Centre
RS	Radio Sonde
RSMC	Regional Specialised Meteorological Centre
RTH	Regional Telecommunication Hub
RW	Radio Wind
S&T	Science and Technology
SAC	Space Applications Centre
SACC	Scientific Advisory Committee to the Cabinet
SCA	Service Centre Agency
SCPC	Single Channel per Carrier
SCS	Satellite Communication System
SDA	State Designated Agency
SDC	State Data Centres
SDMA	State Disaster Management Authorities
SDRF	State Disaster Response Force
SDSS	Spatial Decision Support System
SEC	State Executive Committee
SEOC	State Emergency Operations Centre
SERC	Structural Engineering Research Centre
SEZ	Special Economic Zone
SFR	State of the Forest Report
SHG	Self-Help Group
SHIFOR	Statistical Hurricane Intensity Forecast
SHIPS	Statistical Hurricane Intensity Prediction Scheme
SIRD	State Institute of Rural Development
SMS	Short Message Service
Sol	Survey of India
SOPs	Standard Operating Procedures
SRSA	State Remote Sensing Agency
SSM/I	Special Sensor Microwave/Imager
STIFOR	Statistical Typhoon Intensity Forecast
SW	Short Wave
SWAN	State-Wide Area Network
TC	Tropical Cyclone
TDM	Time Division Multiplex
TIPS	Typhoon Intensity Prediction Scheme
TRAI	Telecom Regulatory Authority of India
TRMM	Tropical Rainfall Measuring Mission

UAV	Unmanned Aerial Vehicle
UFS	User-Facing Service
UGC	University Grants Commission
UKMO	United Kingdom Meteorological Office
ULB	Urban Local Body
USWS	United States Weather Service
UT	Union Territory
VHF	Very High Frequency
VIC	Village Information Centre
VKC	Village Knowledge Centre
VPN	Virtual Private Network
VR	Virtual Reality
VRC	Village Resource Centre
VSAT	Very Small Aperture Terminal
VSS	Vana Samrakshana Samithies
VTF	Village Task Force
VF	Village Volunteer Force
WMO	World Meteorological Organisation
ZSI	Zoological Survey of India

# Glossary of Terms

## Astronomical Tides

The tidal levels and character which would result from gravitational effects, e.g., of the Earth, Sun and Moon, without any atmospheric influences.

## Bathymetry

The measurement of depth of water in oceans, seas and lakes; also information derived from such measurements.

## Best-track Data

Are also used to define probability distribution for characteristics of tropical cyclones (e.g., forward motion and intensity) in a risk model.

## Breakwaters

Breakwaters are structures placed offshore to dissipate the energy of incoming waves. The breakwaters are smaller structures, placed one to three hundred feet offshore in relatively shallow water, designed to protect a gently sloping beach.

## Cliffs

A high, steep face of rock; a precipice.

## Creek

A notable physiographic feature of salt marshes, especially low marshes, in the development of tidal creeks in the marsh itself. These creeks develop, as do rivers, 'with minor irregularities sooner or later causing the water to be deflected into definite channels'.

## Cyclone

A weather system consisting of an area of low pressure, in which winds circulate at speeds exceeding 61 km/hr, also known as 'Cyclone' or Tropical Storm. These are non-frontal synoptic scale weather systems originating over tropical waters with organized convection and definite cyclonic surface wind circulation. Winds rotate around the low pressure centre in an anti-clockwise direction in the Northern Hemisphere and in a clockwise direction in the Southern Hemisphere.

## Decision Support System (DSS)

Generation of hazard maps in respect of habitation of different infrastructure, housing and crop damages based on the cyclone wind distribution of storm surge and heavy rainfall along the cyclone track starting from its coastal landfall.

**Depression (low pressure area)**

Region where the barometric pressure is lower relative to that in the surrounding regions at the same level and wind speed in circulation is between 17 and 27 knot (31 and 49 kmph).

**Doppler Radar**

A radar capable of measuring the change in frequency of a radar wave caused by the relative motion of an object in the atmosphere within the area of radar coverage. Doppler capabilities are not used in the process of converting radar echoes to precipitation estimates.

**Elements at Risk**

The population, properties, economic activities, including public services, etc. at risk in a given area.

**Environmental Impact Assessment (EIA)**

Studies undertaken in order to assess the effect on a specified environment of the introduction of any new factor, which may upset the current ecological balance.

**Estuaries**

An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from 'land drainage'.

**Evacuation**

Organised, phased and supervised dispersal of people from dangerous or potentially dangerous areas.

**Eye of the Cyclone**

A term used for the centre of a cyclone. It is the point where the wind rotates in a counter-clockwise direction. In the centre of eye the wind is calm or slight and rainfall and cloudiness is nil or light.

**Gale**

Wind with a speed between 34 and 40 knots (Beaufort scale wind force 8).

**Knot**

A knot is a unit of speed and used around the world for maritime and aviation purposes. 1 international knot = 1 nautical mile per hour = 1.852 kilometres per hour.

**Landfall**

A point on the land where a cyclone just crosses the coast.

**Land-use Planning**

Branch of physical and socio-economic planning that determines the means and assesses the values or limitations of various options in which land is to be utilized, with the corresponding effects on different segments of the population or interests of a community taken into account in resulting decisions.

### Lead Time

Period of a particular hazard between its announcement and arrival.

### Mangrove

Mangroves are basically halophytic trees, shrubs, and other plants growing on sheltered shores, typically on tidal flats, deltas, estuaries, bays, creeks and the barrier islands. The best locations are where abundant silt and fresh water is brought down by rivers or on the backshore of accreting sandy beaches.

### Non-Structural Measures

Non-engineered measures to reduce or avoid possible impacts of hazards such as education, training, capacity development, public awareness, early warning, hazard vulnerability risk analysis, communication, etc.

### Precautionary Principles

Principle adopted by the UN Conference on the Environment and Development (1992) that in order to protect the environment, a precautionary approach should be widely applied, meaning that where there are threats of serious or irreversible damage to the environment, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

### Prevention Principle

This principle allows action to be taken to protect the environment at an early stage.

### Radar (Radio Detection and Ranging)

System to assist in determining at a single station, the direction and distance of an object.

### Radiosonde

A balloon-borne instrument that measures meteorological parameters from the Earth's surface up to 20 miles or more in the atmosphere. The radiosonde measures temperature, pressure and humidity and transmits or 'radios' these data back to Earth. Upper air winds also are determined through tracking of the balloon's ascent.

### Remote Sensing

The technology of acquiring data and information about objects or phenomena with the help of a device that is not in physical contact with it. In other words, remote sensing refers to gathering information about the Earth and its environment from a distance, a critical capability of the *Earth Observing System*.

### Resilience

The capacity of a system to tolerate perturbation or disturbances without collapsing into a qualitatively different state; to withstand shock and rebuild when necessary.

### Response

The principal purpose of emergency response is the preservation of life and property. Response is defined as the 'actions taken in anticipation of, during, and immediately after an emergency to ensure that its effects are minimised, and that people affected are given immediate relief and support'.

**Risk Mapping**

The process of identifying high-risk areas by correlating a hazard to the terrain and to the probability of occurrence. The results of these analyses are usually presented in the form of risk maps which show the type and degree of hazard represented by a natural phenomenon at a given geographic location.

**Runoff**

Rainwater that flows over the land and into streams and lakes; it often picks up soil particles along the way and transports it to streams and lakes.

**Storm Surge**

It is an abnormal rise in the level of water along a shore, primarily as a result of the high winds and low pressures generated with tropical cyclones; generally affects only coastal areas but may intrude some distance inland.

**Structural Measures**

Any physical construction to reduce or avoid possible impact of hazards, which include engineering measures and construction of hazard-resistant and protective structures and infrastructure.

**Tropical Cyclone**

See Cyclone

**Tsunami**

A series of large waves generated by sudden displacement of seawater (caused by earthquake, volcanic eruption or submarine landslide); capable of propagation over large distances and causing a destructive surge on reaching land. The Japanese term for this phenomenon, which is observed mainly in the Pacific, has been adopted for general usage.

**Unmanned Aerial Vehicle (UAVs)**

For collecting special observations from the core cyclone environment in addition to the data collected from land, ocean and space-based observational platforms for facilitating improved cyclone early warning.

**Wetland**

A vegetated eco-system where water is a dominant factor in its development and existence.

**Zonation**

In general, it is the subdivision of a geographical entity (country, region, etc.) into homogenous sectors with respect to certain criteria (for example, intensity of the hazard, degree of risk, same overall protection against a given hazard, etc.).

# Executive Summary

## Background

The Disaster Management Act, 2005 (DM Act, 2005) lays down institutional and coordination mechanism for effective Disaster Management (DM) at the national, state, district and local levels. As mandated by this Act, the Government of India (GoI) created a multi-tiered institutional system consisting of the National Disaster Management Authority (NDMA) headed by the Prime Minister, the State Disaster Management Authorities (SDMAs) by the respective Chief Ministers and the District Disaster Management Authorities (DDMAs) by the District Collectors and co-chaired by Chairpersons of the local bodies. These bodies have been set up to facilitate a paradigm shift from the hitherto relief-centric approach to a more proactive, holistic and integrated approach of strengthening disaster preparedness, mitigation and emergency response.

Soon after the NDMA was set up, a series of consultations were initiated with various stakeholders to facilitate the development of guidelines for strengthening cyclone disaster management. Senior representatives from government departments and agencies, academics, professionals and representatives of multilateral and humanitarian agencies and the corporate sector participated in these meetings. These meetings acknowledged several initiatives taken up by government agencies in the recent past which are significant and have far-reaching consequences. They also highlighted the need for a holistic and integrated strategy. On the basis of these deliberations, the NDMA has prepared these *Guidelines for the Management of Cyclones* (hereinafter referred to as the Guidelines) to assist ministries and departments of GoI and state governments to prepare their DM plans.

## Cyclone Vulnerability in India

A long coastline of about 7,516 km of flat coastal terrain, shallow continental shelf, high population density, geographical location and physiological features of its coastal areas makes India, in the North Indian Ocean (NIO) Basin, extremely vulnerable to cyclones and its associated hazards like storm tide (the combined effects of storm surge and astronomical tide), high velocity wind and heavy rains.

Though the frequency of Tropical Cyclones (TCs) in the NIO covering the Bay of Bengal and the Arabian Sea is the least in the world (7% of the global total), their impact on the east coast of India as well as the Bangladesh coast is relatively more devastating. This is evident from the fact that in the last 270 years, 21 of the 23 major cyclones (with a loss of about 10,000 lives or more) worldwide occurred over the area surrounding the Indian subcontinent (India and Bangladesh). This is primarily due to the serious storm tide effect in the area.

Thirteen coastal states and Union Territories (UTs) in the country, encompassing 84 coastal districts, are affected by tropical cyclones. Four states (Tamil Nadu, Andhra Pradesh, Orissa and West Bengal) and one UT (Puducherry) on the east coast and one state (Gujarat) on the west coast are more vulnerable to hazards associated with cyclones.

## Broad-Scale Assessment

About 8% of the area in the country is prone to cyclone-related disasters. Recurring cyclones account for large number of deaths, loss of



livelihood opportunities, loss of public and private property and severe damage to infrastructure, thus seriously reversing developmental gains at regular intervals.

Broad-scale assessment of the population at risk suggests that an estimated 32 crore people, which accounts for almost a third of the country's total population, are vulnerable to cyclone-related hazards. Climate change and its resultant sea-level rise can significantly increase the vulnerability of the coastal population.

## National Cyclone Risk Mitigation Project

The National Cyclone Risk Mitigation Project (NCRMP), to be implemented with financial assistance from the World Bank, is envisaged to have four major components:

- **Component A:** Improvement of early warning dissemination system by strengthening the Last Mile Connectivity (LMC) of cyclone warnings and advisories.
- **Component B:** Cyclone risk mitigation investments.
- **Component C:** Technical assistance for hazard risk management and capacity-building.
- **Component D:** Project management and institutional support.

These components are highly interdependent and have to be implemented in a coherent manner. The planned framework of activities under this project provides end-to-end solutions for effective Cyclone Disaster Management (CDM) in all the 13 coastal states and UTs.

## Structure of the Guidelines

A paradigm shift in the approach to DM proceeds from the conviction that development

cannot be sustainable unless disaster mitigation is built into the developmental process. The cornerstone of the approach is that mitigation has to be multi-sectoral. It has been universally accepted that returns on mitigation investments are very high. Developing appropriate coping strategies and risk reduction plans, along with greater public awareness, is the high priority agenda for disaster management in India. This will have to be based on:

- i) Enhancing national, state, district and local-level advocacy partnerships and knowledge management for mainstreaming disaster risk reduction.
- ii) Developing hazard risk management tools, methodologies and practices.

These guidelines are an important step towards the development of plans for the management of cyclones and their attendant disasters. These have been prepared to provide guidance to the ministries, departments and state authorities for the preparation of their detailed DM plans. These guidelines call for a proactive, participatory, well-structured, fail-safe, multi-disciplinary and multi-sector approach at various levels.

**The guidelines are presented in nine chapters as detailed below:**

- i) Chapter 1 provides an introductory overview that reflects the risk and vulnerability of the country to cyclones, including the dimensions and magnitude of the problem.
- ii) Chapter 2 discusses the Early Warning Systems (EWS) for cyclones. In this chapter, the present status of EWSs has been discussed and the gaps have been identified. Requirement to bring them up to international standards and making them state-of-the-art systems has been recommended.

- iii) Chapter 3 deals with the present status of Warning Communication and Dissemination, its gaps and future improvements required towards making it fail-proof and modern.
- iv) Chapter 4 covers structural measures for preparedness and mitigation, covering cyclone shelters, buildings, road links, culverts and bridges, canals, drains, saline embankments surface water tanks, cattle mounds and communication/power transmission networks.
- v) In Chapter 5, important aspects of the management of coastal zones and its relevance to CDM, including some other non-structural mitigation options have been presented. This chapter discusses issues related to coastal zone management, sustainability of coastal resources, bio-shields, coastal flood plain management, coastal erosion, natural resources management, etc.
- vi) Chapter 6 deals with various aspects of awareness generation related to CDM as an important preparedness measure.
- vii) Chapter 7 covers Disaster Risk Management (DRM) issues, risk assessment and vulnerability analysis, hazard zoning and mapping, data generation, including the use of GIS tools, and capacity development.
- viii) Chapter 8 deals with CDM-related response and relief strategies. A detailed account of several issues related to effective response such as response platforms, linking risk knowledge with response planning, evolving disaster response capabilities, etc., is brought out in this chapter.
- ix) In Chapter 9, guidelines and implementation strategies have been discussed. Other supportive mechanisms for effective implementation of guidelines such as preparation of DM and vulnerability reduction

action plans, coordination at all levels of government, mobilization of financial resources and implementation methodology, etc., are discussed.

### Some Salient Action Points

Major Action Points are listed at the end of each chapter. The following are some of the salient initiatives recommended for implementation as part of the National Guidelines for Management of Cyclones:

1. Establishing a state-of-the-art cyclone EWS involving observations, predictions, warnings and customised local-scale advice for decision-makers (national/state/district level) for managing the impact of cyclones.

[Action: Ministry of Earth Sciences (MoES)—India Meteorological Department (IMD) with academic and R&D institutions; Operations Centre (OC) of the NDMA/MHA] [Time-frame: 2008–09 to 2010–11]

2. Commissioning of Aircraft Probing of Cyclone (APC) facility for India with a combination of manned aircraft and high altitude Unmanned Aerial Vehicles (UAV) which can effectively fill the critical observational data gaps in the case of cyclones over the Bay of Bengal and the Arabian Sea to a great extent. An actual flight by an aircraft into and around the tropical cyclone during various stages of its development and movement can provide invaluable data for studying and understanding the structure and movement of a cyclone, thus reducing track and intensity prediction errors significantly.

[Action: Ministry of Earth Sciences (MoES)—IMD, Ministry of Defence—Indian Air Force/ Indian Navy; Department of Space (DoS)—National

- Remote Sensing Agency (NRSA)] [Time-Frame: 2008–09 to 2011–12]
3. Commissioning of the National Disaster Communication Infrastructure (NDCI) at the NDMA/MHA, State Disaster Management Authorities (SDMAs) of coastal states/UTs and District Disaster Management Authorities (DDMAs) of the 84 coastal districts vulnerable to cyclones with the adoption of state-of-the-art operational infrastructure covering the following:
    - i) High End Computing (scalable 30–50 Teraflops peak performance), Storage (800 Terabytes) and Communication Network (Gigabit Ethernet) Infrastructure;
    - ii) 3-D Virtual Reality Visual Studio;
    - iii) Centralised Comprehensive Databank for Cyclone Risk Management with nodes in various coastal states over a fail-safe communication backbone between the OCs of NDMA, SDMAs and DDMAs (for Information and Data Fusion involving collating, analysing, interpreting, translating and monitoring of early warnings from line departments based on state-of-the-art scientific and technological know-how); and
    - iv) Comprehensive state-of-the-art OC for effective coordination of Disaster Response Actions at the state and local levels.

[Action: Operations Centres (OC) of NDMA; Ministry of Home Affairs (MHA); Survey of India (Sol); Department of Space (DoS); Ministry of Earth Sciences (MoES); Department of Science and Technology (DST—National Spatial Data Infrastructure (NSDI)] [Time-Frame: 2008–09 to 2009–10]
  4. Expanding the warning dissemination outreach by using the services of Direct-To-Home (DTH) transmission in remote and rural areas (Panchayats) which cannot be otherwise covered, to introduce weather channel and broadcast cyclone warnings from high-power coastal radio stations including the use of satellite radio service like World Space, Ham radios, community radio and VHF network.
 

[Action: Ministry of Information and Broadcasting (MoI&B); Ministry of Earth Sciences (MoES)] [Time-Frame: 2008–09 to 2011–12]
  5. The following specific actions will be carried out for taking structural measures for cyclone risk mitigation:
    - i) Structural safety of lifeline infrastructure in coastal areas;
    - ii) Establishing a robust system of locating multi-purpose cyclone shelters and cattle mounds;
    - iii) Ensuring cyclone resistant design standards are incorporated in the rural/urban housing schemes in coastal areas;
    - iv) Building all-weather road links to all coastal habitations, between habitations and cyclone shelters/cattle mounds;
    - v) Maintaining the full designed carrying capacity of main drains and canals along with feeder primary/secondary/tertiary channels, creating additional flood flow canals in frequently inundated areas;
    - vi) Construction of saline embankments to prevent ingress of saline water associated with cyclonic storm surge; and

- vii) Encouraging public-private partnership with corporate/trusts.

[Action: Ministry of Urban Development and Poverty Alleviation; Bureau of Indian Standards (BIS); Engineering, Country and Town Planning, Municipal Administration, Panchayati Raj and Planning Departments; Development Authorities; Planning Boards of Coastal States and UTs] [Time-Frame: 2008–09 to 2011–12]

- 6. Actions for effective cyclone risk reduction through management of coastal zones include:

- i) Mapping and delineation of coastal wetlands, patches of mangroves and shelterbelts, identification of potential zones for expanding bio-shield spread based on remote sensing tools.

[Time-Frame: 2008–09 to 2009–12]

- ii) Regulating infrastructure and development activities in coastal zones.

[Time-Frame: 2008–09 to 2009–12]

- iii) Monitoring of water quality as well as the carrying and assimilative capacities of open waters with institutionalised remedial measures.

[Time-Frame: 2008–09 to 2009–12]

- iv) Developing Integrated Coastal Zone Management (ICZM) frameworks for addressing the sustainability and optimal utilisation of coastal resources as also cyclone impact minimisation plans.

[Time-Frame: 2008–09 to 2011–12]

- v) Evolving eco-system restoration plans for degraded ecological zones.

[Time-Frame: 2008–09 to 2011–12]

- vi) Developing delta water management and freshwater recharge/management options.

[Time-Frame: 2008–09 to 2010–12]

- vii) Coastal bio-shields spread, preservation and restoration/regeneration plans.

[Time-Frame: 2008–09 to 2011–12]

- viii) Implementing coastal flood zoning, flood plain development and flood inundation management and regulatory plans.

[Time-Frame: 2008–09 to 2011–12]

- ix) Groundwater development and augmentation of freshwater requirement in coastal urban centres.

[Time-Frame: 2008–09 to 2011–12]

- x) Development of Aquaculture Parks in the identified potential zones.

[Time-Frame: 2008–09 to 2011–12]

[Action: Ministry of Environment and Forests (MoEF); Department of Space (DoS); Ministry of Water Resources (MoWR), Coastal States and UTs; State Remote Sensing Agencies (SRSAAs); Coastal Area Development, and Irrigation and Command Area Development Authorities; Central and State Groundwater Development Authorities and Boards]

7. Setting up of an exclusive eco-system monitoring network to study the impact of changing climate.  
[Action: Ministry of Environment and Forests (MoEF); Department of Science and Technology (DST); Department of Space (DoS); Ministry of Earth Sciences (MoES); Institutions under the Council of Scientific and Industrial Research (CSIR); Technical and Scientific Institutions under the Governments of Coastal States and UTs] [Time-Frame: 2008–09 to 2011–12]
8. Developing integrated hazard mitigation framework taking into account cyclone and associated storm surge, wind hazard, rainfall-runoff, river flood and Geographical Information System (GIS) models for estimating possible areas of inundation along with the depth of inundation (levels), possible damage to infrastructure, crops, houses, etc., evaluating not only the vulnerability but also the changing profile of vulnerability from time to time.  
[Action: Ministry of Earth Sciences (MoES); Ministry of Water Resources (MoWR); State Remote Sensing Agencies (SRSAs); Disaster Management Departments of Coastal States and UTs] [Time-Frame: 2008–09 to 2009–12]
9. Integrate ongoing efforts of the Survey of India, Department of Space under National Spatial Data Infrastructure, National Database for Emergency Management and MoEF initiatives for speedy completion of digital spatial data generation to cover 84 coastal districts that are vulnerable to cyclones, for evolving holistic cyclone risk reduction strategies on priority. High resolution (at least 0.5 m interval) coastal Digital Elevation Models (DEMs) are to be developed for micro-scale delineation of cyclone risk, hazard and vulnerability.  
[Action: Department of Science and Technology (DST); Survey of India (SoI); Department of Space (DoS); National Database for Emergency Management (NDEM); National Spatial Data Infrastructure (NSDI); Ministry of Environment and Forests (MoEF); State Remote Sensing Agencies (SRSAs); Technical and Scientific Institutions of Coastal States and UTs] [Time-Frame: 2008–09 to 2009–12]
10. Augmentation of additional surveys by the Census Commissioner will be carried out for generating household, disaster specific attribute data.  
[Action: Ministry of Planning and Programme Implementation; Central Statistical Organisation (CSO), National Sample Survey Organisation (NSSO); Directorates of Economics and Statistics (DES) in Coastal States and UTs] [Time-Frame: 2008–09 to 2009–12]
11. Establishing a comprehensive Cyclone Disaster Management Information System (CDMIS) covering all phases of DM to provide on-line services to the departments of Disaster Management in the states.  
[Action: Directorates of Economics and Statistics (DES), State Departments of Information and Communication Technologies (ICT) Planning, Coastal Area Development and Irrigation and Command Area Development Authorities, State Remote Sensing Agencies (SRSAs), Disaster Management Departments of Coastal States and UTs] [Time-Frame: 2008–09 to 2009–12]

12. Specifying the roles and responsibilities of the State Disaster Management Departments in institutionalising Cyclone Risk Mitigation with Developmental Planning.

[Action: State Disaster Management Authorities (SDMAs) in Coastal States and UTs] [Time-Frame: 2008–09 to 2010–12]

13. Launching Community Based Disaster Management (CBDM) activities similar to the DRM Project initiatives of MHA in all villages of the 84 districts vulnerable to cyclones that have not yet been covered.

[Action: SDMAs in Coastal States and UTs] [Time-Frame: 2008–09 to 2011–12]

14. NCDMI will be established as an exclusive institutional set-up in one of the coastal states to address all issues related to cyclone risk. NDMA will conceptualise the entire project. NCDMI will involve stakeholders from the government and the community, focusing on preparedness, mitigation, response, rehabilitation and

recovery. It will bridge the gap in the integration of disaster related technical support of all the concerned departments/ministries of the Central Government with those of the states/UTs and local authorities. It will serve as a platform for all academics and S&T institutions to synergise their efforts to offer better disaster risk reduction options.

[Action: National Disaster Management Authority (NDMA); Operations Centres (OCs) of Ministry of Home Affairs (MHA); Ministry of Earth Sciences (MoES)—IMD; Department of Science and Technology (DST)—Sol; DoS-NRSA; Ministry of Water Resources (MoWR)—CWC; SDMAs] [Time-Frame: 2008–09 to 2009–10]

15. Institutionalising specific Emergency Response (ER) Actions for Cyclone Disaster Management.

[Action: SDMAs in Coastal States and UTs] [Time-Frame: 2008–09 to 2011–12]



Figure 1 (a): Cyclone Frequency and Wind Hazard Map

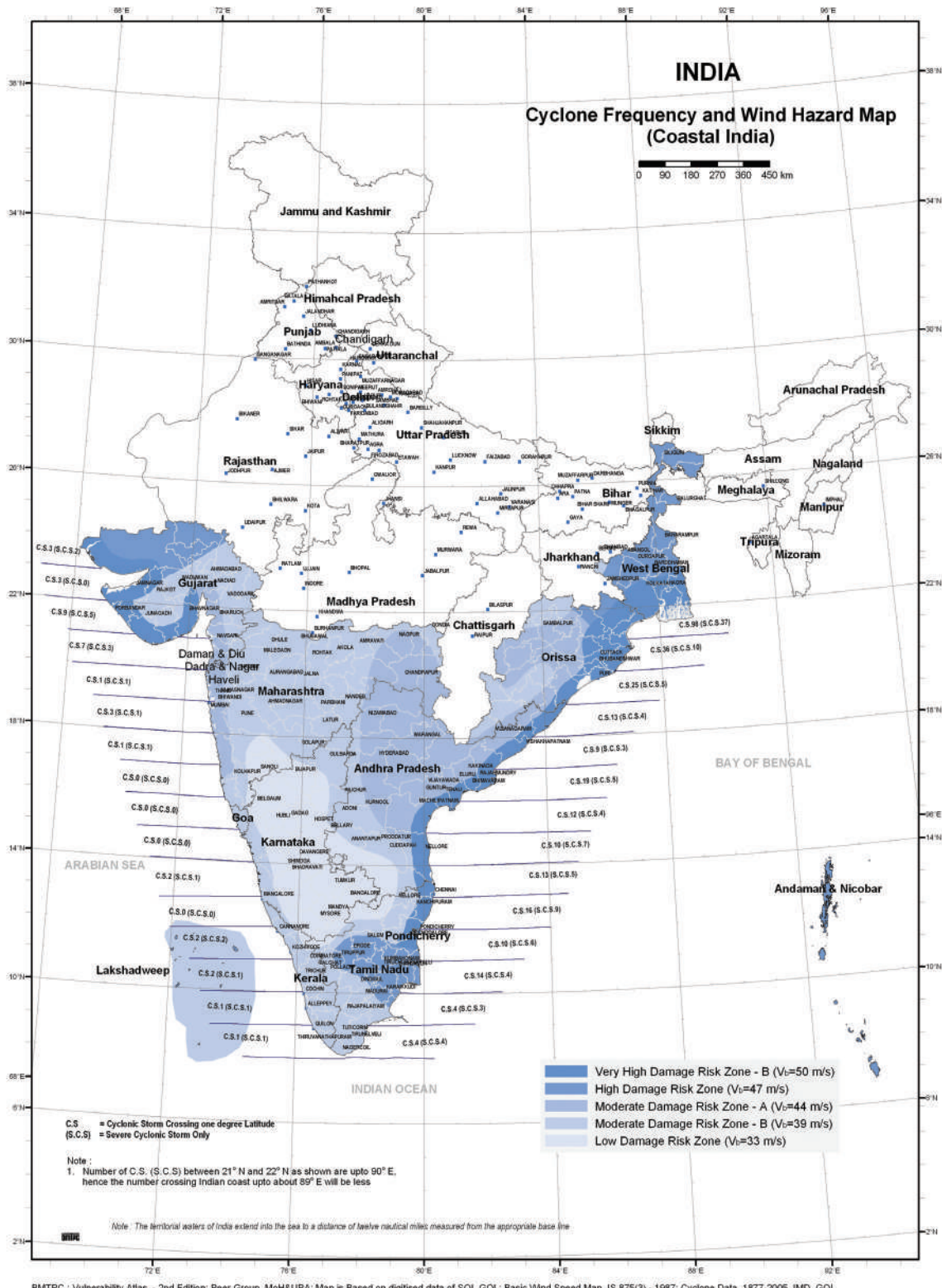
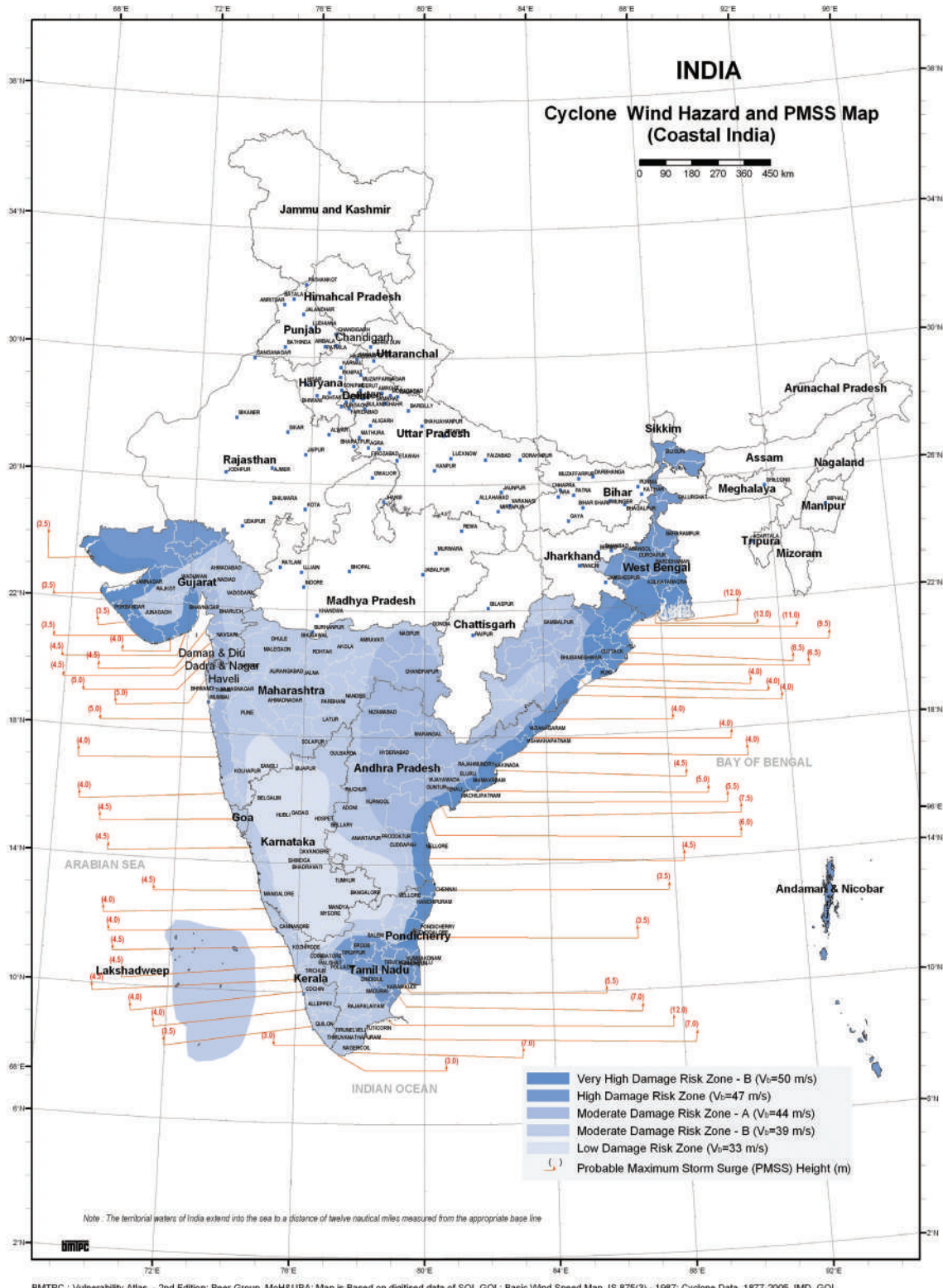






Figure 1 (b): Cyclone Wind Hazard and PMSS Map





## 1.1 Overview

1.1.1 Tropical Cyclone (TC), also known as 'Cyclone' is the term used globally to cover tropical weather systems in which winds equal or exceed 'gale force' (minimum of 34 knot, i.e., 62 kmph). These are intense low pressure areas of the earth-atmosphere coupled system and are extreme weather events of the tropics.

1.1.2 India has a coastline of about 7,516 km, 5,400 km along the mainland, 132 km in Lakshadweep and 1,900 km in the Andaman and Nicobar Islands. Although the North Indian Ocean (NIO) Basin (including the Indian coast) generates only about 7% of the world's cyclones, their impact is comparatively high and devastating, especially when they strike the coasts bordering the North Bay of Bengal.

1.1.3 The frequency of cyclones in the NIO Basin is bi-modal, which is specific to this region. Cyclones occur in the months of May–June and October–November, with their primary peak in November and secondary peak in May.

1.1.4 Tropical cyclones generally originate in the eastern side of the NIO Basin and initially move in a west-north westerly direction. More cyclones form in the Bay of Bengal than in the Arabian Sea and the ratio is 4:1. It has been observed that between 1891 and 2006, 308 cyclones crossed the east coast, out of which 103 were severe. Less cyclonic activity was observed on the west coast during the same period, with 48 cyclones crossing the west coast, out of which 24 were of severe intensity.

1.1.5 Tropical cyclones are characterised by destructive winds, storm surges and very heavy rainfall, each one having its own impact on human and livestock, and their activities. Of these, storm surge is responsible for 90% of the loss of lives associated with cyclone disaster. Past records of destructive cyclones (human deaths numbering around 10,000 and above) are given in Table 1.1. This list does not include TCs which have caused severe loss to properties (such as 'Katrina' in USA in 2005 which has resulted in economic losses of about US\$ 82 billion) or the severest TC ever recorded in terms of intensity ('Typhoon Tip' in the Pacific Ocean). However, it has been observed the world over that even though damage to property is continuously increasing loss of life shows a declining trend. This is because of improved early warning system and dissemination, various risk reduction measures, preparedness, mitigation measures and improved response mechanisms.

1.1.6 It can be seen that since 1737, 21 of the 23 major cyclone disasters (in terms of loss of lives) in the world have occurred over the Indian subcontinent (India and Bangladesh). Tropical cyclones in the Bay of Bengal striking the east coast of India and Bangladesh usually produce a higher storm surge as compared to elsewhere in the world because of the special nature of the coastline, shallow coastal bathymetry and characteristics of tides. Their coastal impact is significant because of the low flat coastal terrain, high density of population, low awareness of the community, inadequate response and preparedness and absence of any hedging mechanism.

**Table 1.1 Major Tropical Cyclone Disasters during the past 270 Years in terms of Human Loss (with Human Deaths 10,000 or more)**

Sl. No.	Year	Country	Deaths
1	1737	Hooghly, West Bengal, India	300,000
2	1779	Machilipatnam, Andhra Pradesh, India	20,000
3	1782	Coringa, Andhra Pradesh, India	20,000
4	1787	Coringa, Andhra Pradesh, India	20,000
5	1788	The Antilles, Carribean Islands, West Indies	22,000
6	1822	Barisal/Backergunj, Bangladesh	50,000
7	1831	Balasore, Orissa, India	22,000
8	1833	Sagar Island, West Bengal, India	30,000
9	1839	Coringa, Andhra Pradesh, India	20,000
10	1864	Machilipatnam, Andhra Pradesh, India	30,000
11	1867	Contai, West Bengal, India	50,000
12	1876	Backergunj, Bangladesh	200,000–250,000
13	1881	China	300,000
14	1897	Bangladesh	175,000
15	1942	Contai, West Bengal, India	15,000
16	1961	Bangladesh	11,468
17	1963	Bangladesh	11,520
18	1965	Bangladesh	19,229
19	1970	Bangladesh	300,000
20	1971	Paradip, Orissa, India	10,000
21	1977	Divi Seema, Andhra Pradesh, India	10,000
22	1991	Bangladesh	138,000
23	1999	South of Paradip, Orissa, India	9,893 *

**Source:** CRC Report, HPC Report, IMD Publications.

\*Population affected 15,681,072.

1.1.7 There are 13 coastal states and union territories (UTs) in the country, encompassing 84 coastal districts which are affected by tropical cyclones. Four states (Tamil Nadu, Andhra Pradesh, Orissa and West Bengal) and one UT (Puducherry) on the east coast and one state (Gujarat) on the west coast are highly vulnerable to cyclone disasters. The details of cyclones which crossed

the coastal districts of India during the period 1891–2006, is presented in Table 1.2.

## 1.2 Cyclogenesis

1.2.1 Cyclones are atmospheric and oceanic phenomena. Listed below are some of the favourable conditions identified through

Table 1.2 Number of Cyclones crossing various Coastal Districts of the East and West Coasts of India during the Period 1891–2002

WEST COAST			EAST COAST		
State	Coastal Districts	No. of Cyclones	State	Coastal Districts	No. of Cyclones
<b>Kerala</b> (3)	Malappuram	1	<b>W. Bengal</b> (69)	24 Parganas (North and South)	35
	Kozikode	1		Midnapur	34
	Kannur	1			
<b>Karnataka</b> (2)	Dakshina Kannada	1	<b>Orissa</b> (98)	Balasore	32
	Uttar Kannada	1		Cuttack	32
<b>Maharashtra</b> (13)			<b>Andhra Pradesh</b> (79)	Puri	19
	Sindhudurg	3		Ganjam	15
	Ratnagiri	3			
	Mumbai	3		Srikakulam	14
	Thane	4		Visakhapatnam	9
<b>Goa</b> (2)	Goa	2	<b>Tamil Nadu</b> (54)	East Godavari	8
				West Godavari	5
<b>Gujarat</b> (28)	Surat	1	<b>Puducherry (UT)</b>	Krishna	15
	Kaira	1		Guntur	5
	Bhavnagar	4		Prakasam	7
	Amreli	4		Nellore	16
	Junagarh	7		Chennai	18
	Jamnagar	6		Cuddalore	7
	Kachchh	5		Southarcot	5
			Tanjavur	12	
			Pudukkottai	5	
			Ramnathpuram	3	
			Tirunelveli	2	
			Kanyakumari	2	
			Puducherry	8	

Source: IMD:2002: Damage Potential of TC

observational facts and scientific studies for the formation of TCs. The weightage of individual conditions is, however, yet unknown.

- i) A warm sea surface (temperature in excess of 26°–27°C) and associated warming
- ii) High relative humidity in the atmosphere up to a height of about 5,000 metres,

extending up to a depth of 60m with abundant water vapour in the overlying air (by evaporation),

- iii) Atmospheric instability that encourages the formation of massive vertical cumulus clouds due to condensation of rising moist air,
- iv) Low vertical wind shear between the lower and higher levels of the atmosphere that do not allow the heat generated and released by the clouds to get transported from the area (vertical wind shear is the rate of change of wind between the higher and lower levels of the atmosphere),
- v) The presence of cyclonic vorticity (rate of rotation of air) that initiates and favours rotation of the air cyclonically, and
- vi) Location over the ocean, at least 4–5° latitude away from the equator.

in Southern Hemisphere, though the wind at the centre (known as eye of the cyclone) is very little and generally free from cloud and rain. Winds increase rapidly to its peak (often exceeding 150 km/h) at about 20 to 30 km from the centre and thereafter decrease gradually to become normal around 300 to 500 km away. Cyclones vary in diameter from 100 to 1,000 km but their effect dominates over thousands of square kilometres over the ocean as well as along the coast. The powerhouse is located within a 100 km radius of the eye of the cyclone where very strong winds, sometimes more than 250 km per hour, can be generated in a narrow zone beyond the eye diameter.

### 1.3 Frequency

1.2.2 Within the cyclone field, strong winds blow around the low pressure centre in an anticlock-wise direction in the Northern Hemisphere and clockwise

1.3.1 The frequency of cyclonic disturbances that formed in the Bay of Bengal between 1891 and 2000 is shown in Table 1.3.

**Table 1.3 Various Types of Cyclonic Disturbances formed in the Bay of Bengal Affecting the East Coast of India between 1891 and 2000**

Type of Disturbance	Cyclonic Disturbance	Depression/Deep Depression	Cyclonic Storm	Severe Cyclonic Storm and Above
Number	1087	635	279	173
Maximum (1891–1991)	158 (Aug.)	131 (Aug.)	51 (Oct.)	38 (Nov.)
Minimum (1891–1991)	4 (Feb.)	1 (Mar.)	0 (Feb.)	1 (Jan.)
Yearly average	10	6	3	1.5
Per cent of total	--	58	26	16
Wind speed (km/h)	31 or more	31–61	62–88	89 and more

Source: India Meteorological Department.

## 1.4 Classification

1.4.1 Cyclones are known by many names the world over—typhoons in the North West Pacific including the South China Sea, hurricanes in the North Atlantic including the West Indies and in the Caribbean Sea and the North East Pacific, the aboriginal name of Willy-Willies in North-Western Australia and TCs in the North and South Indian Ocean.

1.4.2 Though TCs differ by name across regions, they are classified according to their wind speed. The classification, however, varies from region to region. The Indian classification of these intense low pressure systems (cyclonic disturbances) is shown in Table 1.4.

**Table 1.4 Indian Classification of Cyclonic Disturbances in the North Indian Ocean (Bay of Bengal and Arabian Sea)**

Type	Wind Speed in km/h	Wind Speed in Knots
Low Pressure area	Less than 31	Less than 17
Depression	31–49	17–27
Deep Depression	50–61	28–33
Cyclonic Storm	62–88	34–47
Severe Cyclonic Storm	89–118	48–63
Very Severe Cyclonic Storm	119–221	64–119
Super Cyclone	222 or more	120 or more

Source: India Meteorological Department.

1.4.3 In the US, cyclones are classified into five different categories on the basis of their wind speed as measured on the Saffir-Simpson scale. This classification is given in Table 1.5.

**Table 1.5 Saffir-Simpson Hurricane Scale**

Scale Number (Category)	Sustained Winds in m/h	Damage	Storm Surge
1	74–95 (64–82 kt)	Minimal: Unanchored mobile homes, vegetation, and signs	4–5 feet
2	96–110 (83–95 kt)	Moderate: All mobile homes, roofs, small craft; flooding	6–8 feet
3	111–130 (96–113 kt)	Extensive: Small buildings, low-lying roads cut off	9–12 feet
4	131–155 (114–35 kt)	Extreme: Roofs destroyed, trees down, roads cut off, mobile homes destroyed, beach homes flooded	13–18 feet
5	156 or more (135 kt or more)	Catastrophic: Most buildings destroyed, vegetation destroyed, major roads cut off, homes flooded	Greater than 18 feet

Source: National Weather Services (NWS), National Oceanic and Atmospheric Administration (NOAA)

Note: Tropical Storms: winds 39–73 mph (34–63 kt)



## 1.5 Impact

1.5.1 Cyclones are characterized by their destructive potential to damage structures such as houses, lifeline infrastructure such as power and communication towers, hospitals, food storage facilities, roads, bridges, culverts, crops, etc., due to high velocity winds.

1.5.2 Exceptionally heavy rainfall causes flooding. Storm surge inundates low-lying areas in the coastal areas resulting in loss of life and destruction of property, besides eroding beaches and embankments, destroying vegetation and reducing soil fertility.

1.5.3 The dangerous dimension of cyclone disasters over the Indian subcontinent is evident from the figures in Table 1.1 showing the number of deaths due to cyclone disasters from 1737 onwards. Besides the loss of lives and livestock, cyclones have high destructive potential due to the strong winds that damage structures, and heavy rainfall which causes floods and storm surge that inundates low-lying coastal areas.

1.5.4 Although it is not possible to completely avoid natural disasters, their effects can be minimised by taking some known long- and short-term structural and non-structural mitigation measures such as developing proper early warning systems, creating awareness at all levels in the concerned communities, coastal afforestation, construction of shelters, embankments, dykes, coastal roads, bridges, canals, etc., through better preparedness, mitigation measures and improved response mechanisms.

## 1.6 Naming of Tropical Cyclones

1.6.1 Tropical cyclones are named to enable easy identification and to eliminate confusion when there are multiple systems in any individual basin at the

same time, and to assist people to identify the system from which danger is most imminent. In most cases, TCs retain their names throughout their life; however, under special circumstances, TCs may be renamed while active. These names are taken from lists which vary from region to region and are selected a few years earlier. The list is decided upon, depending on the region, either by committees of the World Meteorological Organisation (WMO) or by national weather offices (IMD in India) involved in the forecasting of cyclones. Each year, the names of highly destructive cyclones are 'retired', to be replaced by new ones.

## 1.7 Storm Surge

1.7.1 Storm surge, which is a coastal phenomena, is the inherent catastrophic feature of cyclones the world over. The degree of disaster potential depends on the storm surge amplitude associated with the cyclone at the time of landfall, characteristics of the coast, phases of the tides and vulnerability of the area and community. The world's highest recorded storm tide was about 12.5 m (about 41 ft) and it was associated with the Backergunj cyclone in 1876 near the Meghna estuary in present-day Bangladesh. A storm tide of closer magnitude (12.1 m) was also observed in West Bengal at the mouth of the Hooghly River in association with a severe cyclone in October 1737. When a cyclone approaches the coast, the right forward sector of the cyclone experiences wind from ocean to land (on-shore wind) which pushes the sea water towards the coast and finally appears as storm surge. The direction of the wind on the left forward sector of the cyclone is from land to ocean (off-shore wind) which pushes the water from the coast towards the ocean producing even negative surge.

1.7.2 As explained at the outset, although the impact of cyclones is generally devastating over the coastal areas of West Bengal and Orissa, bordering the North Bay of Bengal, the effects of



cyclones are also pronounced in the states/UT of Andhra Pradesh and Tamil Nadu/Puducherry. On the west coast, Gujarat is the most vulnerable state.

1.7.3 The Probable Maximum Storm Surge (PMSS) is the highest along the West Bengal coast where it ranges from 9–12.5 m. It reduces to about 3.8 m in Khurda district, Orissa, increasing again to about 8.2 m along the south Andhra Pradesh coast in Krishna, Guntur and Prakasam districts. A small region in south Tamil Nadu around Nagapattinam coast also has higher PMSS of about 8.4 m. Along the west coast, the PMSS varies from about 2 m near Thiruvananthapuram to around 5 m near the Gulf of Khambat in the Saurashtra region of Gujarat.

1.7.4 The super cyclone of October 1999 generated a wind speed of 252 km/h with an ensuing surge of 7–9m close to Paradip in Orissa which caused unprecedented inland inundation up to 35 km from the coast. It is worth noting that, at times, persistent standing water was identified in the satellite imageries even 11 days after the cyclone landfall, as it happened in the Krishna delta in May 1990 and in several other instances. The Andhra Pradesh cyclone in 1977 which hit Divi Seema also generated winds exceeding 250 km per hour.

## 1.8 Broad Scale Assessment

1.8.1 The *Vulnerability Atlas of India* (1997) contains cyclone hazard maps for the country as a whole, depicting the vulnerability of states/UTs to cyclones on a macro scale.

1.8.2 Vulnerability to natural disasters like cyclones can be conceptualised as the exposure to hazard (cyclone) and coping capacity of the people, and the institutional support (e.g., early warning systems and capacity-building) to adapt and reduce adverse impacts. This coping capacity also includes defence mechanisms and access to

resources (e.g., education and infrastructure) as well as emergency response systems.

1.8.3 Broad scale assessment of the population at risk suggests that an estimated 32 crore people, which accounts for almost a third of the country's total population, are vulnerable to cyclone-related hazards. Climate change and its resultant sea-level rise can significantly increase the vulnerability of the coastal population.

1.8.4 Further, analysis combining storm risk and poverty suggests that Orissa is most vulnerable due to its low coping capacity (per capita income of Rs 6,767 and cyclonic vulnerability). Tamil Nadu, Andhra Pradesh and West Bengal are also vulnerable because they lie in the high cyclone hazard zones and also have low per capita incomes. Maharashtra and Goa are the two states which are also affected by cyclones but they are less vulnerable as cyclones are less frequent and people living there have better coping capacity because of higher incomes (per capita income is more than Rs 18,365).

A list of various coastal districts and their broad-scale vulnerability is provided overleaf in Table 1.6.

1.8.5 Cyclone wind hazard along with probable maximum storm surges for coastal districts of India are shown in Fig. 1(a) & (b). [Reference: Building Material Technology Promotion Council (BMTPC), 2007].

## 1.9 Past Initiatives: National Level

1.9.1 Following the extensive damage caused by two cyclones that struck Andhra Pradesh in 1969, the Government of India (Ministry of Irrigation and Power in consultation with the Ministry of Tourism and Civil Aviation) appointed the Cyclone Distress Mitigation Committee (CDMC) in 1970. The CDMC was chaired by the then Director General of

Table 1.6 List of Vulnerable Districts for Cyclone Wind and Coastal/Inland Flooding

S. No.	District	Wind and Cyclone	Coastal/Inland Flooding	S. No.	District	Wind and Cyclone	Coastal/Inland Flooding
<b>Andhra Pradesh</b>				<b>Maharashtra</b>			
1	East Godavari	VH	FLZ	45	Mumbai	H	FLZ
2	Krishna	VH	FLZ	46	Sindhudurg	M	-
3	Guntur	VH	FLZ	47	Raigarh	M	-
4	West Godavari	H	FLZ	48	Ratnagiri	M	-
5	Prakasam	VH	FLZ	49	Thane	H	FLZ
6	Vizianagaram	VH	FLZ	<b>Orissa</b>			
7	Nellore	VH	FLZ	50	Cuttack	VH	FLZ
8	Visakhapatnam	VH	FLZ	51	Ganjam	VH	FLZ
9	Srikakulam	VH	FLZ	52	Jagatsinghpur	VH	FLZ
<b>Goa</b>				53	Kendrapara	VH	FLZ
10	North Goa	M	-	54	Khurdha	VH	FLZ
11	South Goa	M	-	55	Puri	VH	FLZ
<b>Gujarat</b>				56	Balaso	VH	FLZ
12	Amnabad	M	FLZ	57	Bhadrak	VH	FLZ
13	Bharuch	M	FLZ	58	Jajpur	VH	FLZ
14	Kachchh	VH	FLZ	59	Nayagarh	H	-
15	Kheda	M	FLZ	60	Dhenkanal	H	-
16	Surat	M	FLZ	<b>Tamil Nadu</b>			
17	Vadodara	M	FLZ	61	Thanjavur	VH	FLZ
18	Valsad	M	FLZ	62	Cuddalore	VH	FLZ
19	Bhavnagar	M	-	63	Kanchipuram	VH	-
20	Junagadh	VH	FLZ	64	Thiruvallur	VH	-
21	Jamnagar	M	FLZ	65	Tiruvanamalai	VH	-
22	Narmada	H	FLZ	66	Viluppuram	VH	-
23	Navsari	M	FLZ	67	Ramanathapuram	VH	-
24	Anand	M	FLZ	68	Nagapattinam	VH	FLZ
25	Amreli	M	FLZ	69	Pudukottai	H	-
26	Rajkot	M	FLZ	70	Sivaganga	H	-
27	Porbandar	H	FLZ	71	Thoothukudi	VH	FLZ
<b>Karnataka</b>				72	Tirunelveli	VH	-
28	Udupi	M	-	73	Kanyakumari	H	-
29	Mangalore (Dakshina Kannada)	M	-	<b>West Bengal</b>			
30	Uttara Kannada	M	-	74	Bardhaman	H	FLZ
<b>Kerala</b>				75	Kolkata	H	FLZ
31	Ernakulam	M	FLZ	76	Hooghly	VH	FLZ
32	Idukki	M	FLZ	77	North Twenty Four Parganas	VH	FLZ
33	Kannur	M	FLZ	78	South Twenty Four Parganas	VH	FLZ
34	Kasargode	M	FLZ	79	Midnapore	VH	FLZ
35	Kollam	M	FLZ	<b>Union Territories</b>			
36	Kottayam	M	FLZ	80	Puducherry and Karaikal	H	-
37	Kozhikode	M	FLZ	81	Andaman & Nicobar	H	FLZ
38	Malappuram	M	FLZ	82	Dadra & Nagarhaveli	H	FLZ
39	Palakkad	M	FLZ	83	Daman & Diu	H	FLZ
40	Thiruvananthapuram	M	FLZ	84	Lakshadweep	H	FLZ
41	Thrissur	M	FLZ				
42	Alappuzha	M	FLZ				
43	Wayanad	M	-				
44	Pathanamthitta	M	-				

Source: HPC Report, UNDP and NIDM

Legend: M – Medium; H – High; VH – Very High; FLZ – Flood Zone

Observatories, Dr. P. Koteswaram of the IMD, to review the mitigation efforts on cyclones.

1.9.2 The Committee submitted its report in May 1971 with 59 major recommendations comprising installation and upgrading of the warning system; demarcation of vulnerable areas; relief preparedness; availability of drinking water; restoration of the damaged infrastructure; construction of cyclone shelters, bunds or embankments; a model cyclone plan; cyclone protection measures; educational awareness; coordination committees from different groups; and finally, a calamities fund. Even though this report was directly concerned with the consequences of cyclones for the Andhra Pradesh coast, many of the recommendations were valid for other coastal states/UTs vulnerable to cyclones.

1.9.3 Similar committees were also constituted for the state of Orissa (1971) and West Bengal (1974). The Tamil Nadu Government prepared an anti-disaster plan to meet cyclone emergencies almost simultaneously.

1.9.4 After the November 1977 cyclone that caused huge loss of life and property in Andhra Pradesh, a Committee of Secretaries (CoS) of the Government of India had discussed the issue to find out the status of the implementation of the recommendations of the CDMC in various coastal states and to suggest remedies for any lacunae. The Committee observed in May 1978 that many important recommendations of the CDMC had not been implemented till then. Subsequently, it made its own recommendations and *inter alia* decided to set up an Empowered Committee of Secretaries with the aim of ensuring speedy implementation of the recommendations of the CDMC and modify them, if necessary.

1.9.5 After all these efforts, it was realised that many aspects of cyclone management require further infusion of latest science and technology

(S&T) developments for satisfactory solutions. In 1979, the Secretary of the Department of Science and Technology (DST) brought the cyclone issues to the notice of the National Committee of Science and Technology (NCST) that was subsequently named the Scientific Advisory Committee (SAC) to the Prime Minister. The Secretary, DST, suggested that a Cyclone Review Committee (CRC) should be set up under the auspices of the NCST to carry out a complete review of all aspects of cyclone management. The CRC submitted its report along with recommendations in 1984.

1.9.6 Apart from some institutional arrangements related to the operational issues of cyclone warning, till date the major recommendations of the CRC have not been implemented. One of the major recommendations was to commission the Aircraft Probing of Cyclone (APC) facility for India to generate critical observations from the cyclone core environment.

1.9.7 A High Powered Committee (HPC) on Disaster Management (DM) was constituted in 1999, prior to the Orissa super cyclone, to prepare comprehensive model plans for the management of disasters at the national, state and district levels. Based on its recommendations, state governments have set up State Crisis Management Groups headed by the chief secretaries, designated relief commissioners and put in place state/district contingency plans. A separate Calamity Relief Fund (CRF) has been set up on the recommendation of the IXth Finance Commission for each state where 75% of the fund is contributed by the central government and the remaining is contributed by the various state governments. It was also recommended that Ministry of Home Affairs (MHA) will be notified as the nodal ministry for overall management of disasters which was finally done in 2002 after the devastating Bhuj earthquake. However, the Ministry of Agriculture continues to be the nodal ministry for drought management. Other ministries have been assigned the responsibility of providing emergency support.

## 1.10 Paradigm Shift: Past Initiatives by some States

1.10.1 There have been some efforts in the past by some of the most vulnerable states by taking up institutionalised mitigation efforts. The first effort was the World Bank-assisted Cyclone Emergency Reconstruction Project (CERP) taken up by the Government of Andhra Pradesh in 1990 itself following the severe cyclone of May 1990. This is referred to as one of the first initiatives heralding the paradigm shift to a holistic approach of cyclone risk management in the country.

1.10.2 In the aftermath of another devastating cyclone that affected the north Andhra Pradesh coast in 1996, the Government of Andhra Pradesh has set up a separate Disaster Management Unit (DMU) to implement the World Bank-funded Andhra Pradesh Hazard Mitigation and Emergency Cyclone Recovery Project (APHM & ECRP), and is currently functioning as the Andhra Pradesh State Disaster Mitigation Society (APSDMS).

1.10.3 The Government of Orissa constituted the Orissa State Disaster Mitigation Authority (OSDMA), as a Government owned autonomous body after the October 1999 super cyclone to have a systematic and planned approach to disaster management in the state with the objective of making the people of the state more disaster resilient. OSDMA coordinates various activities of disaster mitigation in the state including capacity-building of the community and disaster managers and strengthening of infrastructure, improvement in communication system, etc.

1.10.4 The Government of Orissa has constituted five units of Orissa Disaster Rapid Action Force (ODRAF) which is specially trained and equipped force to deal with cyclones and other disasters. They are stationed at Jharsugda, Balasore, Cuttack, Chhatrapur and Koraput. In addition to the other modes of communication, Orissa has established an extensive VHF network connecting different

levels of administration and the community to communicate cyclone warnings and advisories. Besides, the state government has undertaken several initiatives for multi-hazard mitigation in the state.

1.10.5 In the aftermath of the Bhuj earthquake in January 2001, a massive reconstruction programme was launched by the Gujarat state government with financial assistance from multi-lateral funding agencies including the World Bank. The Gujarat State Disaster Management Authority (GSDMA) was established for the implementation of the reconstruction programme. Further, GSDMA has come out with a Composite Risk Atlas to help the concerned departments of the state in disaster mitigation planning in the areas most vulnerable to natural and man-made hazards. The taluks most vulnerable to cyclones have been mapped by utilising Geographic Information System (GIS) tools.

## 1.11 Paradigm Shift in DM: Genesis of the DM Act

1.11.1 In the immediate aftermath of the December 2004 tsunami, the Government of India took a far-reaching decision to set up an institutional mechanism for effective DM with a vision to transforming the approach toward DM in the country. In March 2005, the Disaster Management Bill was introduced in both houses of Parliament, which became an Act in December 2005, after it was adopted by Parliament. This initiative has been hailed in all quarters as a defining moment in attempting to organise a paradigm shift in DM. The erstwhile relief-centric and post-event syndrome was set to change to a well-orchestrated process that focuses on the important but neglected areas of prevention, mitigation, preparedness and more robust and efficient measures for response, rehabilitation and recovery.

### 1.11.2 The Disaster Management Act, 2005

1.11.2.1 This Act lays down the institutional, legal, financial and coordination mechanism at the central,

state, district and local levels. These institutions are not parallel structures, and will work in close harmony. The institutional framework will ensure implementation of the national will for a paradigm shift in DM from a post-event and relief-centric syndrome to a regime that lays greater emphasis on preparedness, prevention and mitigation, leading to a more prompt and effective response to disasters. The institutional framework under the DM Act includes the creation of NDMA at the national level, SDMAs at state levels and DDMAAs at district levels.

## 1.12 Institutional Framework

### 1.12.1 National Disaster Management Authority

1.12.1.1 The National Disaster Management Authority (NDMA), as the apex body in the Gol, has the responsibility of laying down policies, plans and guidelines for DM and coordinating their enforcement and implementation for ensuring timely and effective response to disasters. The guidelines will assist the central ministries, departments and states to formulate their respective plans. It will approve the national DM plan prepared by the National Executive Committee (NEC) and plans of the central ministries and departments. It will take such other measures as it may consider necessary, for the prevention of disasters, or mitigation, or preparedness and capacity building, for dealing with a threatening disaster situation or disaster. To this end, it will be the responsibility of every central ministry or department to provide assistance to NDMA, and the state governments will also extend necessary cooperation and assistance. It will oversee the provision and application of funds for mitigation and preparedness measures. It has the power to authorise the departments or authorities concerned, to make emergency procurement of provisions or materials for rescue and relief in a threatening disaster situation or disaster. It will also provide such support to other countries in times of disasters as may be determined by the central

government. The general superintendence, direction and control of the National Disaster Response Force (NDRF) are vested in and will be exercised by the Authority. The National Institute of Disaster Management (NIDM) will work within the framework of the broad policies and guidelines of NDMA.

In essence, NDMA will concentrate on prevention, preparedness, mitigation, rehabilitation, reconstruction and recovery and also formulate appropriate policies and guidelines for effective and synergised national disaster response and relief. It will also coordinate the enforcement and implementation of policies and plans.

### 1.12.2 The National Executive Committee

1.12.2.1 The National Executive Committee (NEC) comprises the secretary to the Gol in the ministry or department having administrative control of the subject of DM, as the chairperson, and the secretaries to the Gol in the ministries/departments of Agriculture, Atomic Energy, Defence, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee as members. Secretary, NDMA will be a special invitee to the meetings of NEC.

1.12.2.2 NEC is the executive committee of NDMA, and is mandated to assist NDMA in the discharge of its functions and also ensure compliance of the directions issued by the central government for the purposes of DM. One of the important functions assigned to NEC is to coordinate the immediate response in the event of any threatening disaster situation or disaster on behalf of NDMA. Based on the policy and guidelines, NEC will be responsible for preparing the national plan, getting it approved by NDMA and then operationalising it. NEC will also require any department or agency of the

government to make available to NDMA or state authorities, such men or material resources as are available with it, for the purposes of handling threatening disasters, emergency response, rescue and relief. It will also perform such other functions as NDMA may require it to perform.

1.12.2.3 The functions presently being discharged by the Inter-Ministerial Group (IMG) in appraising the assessments made by the Inter-Ministerial Central Teams of the damage, the requirement of funds from the National Calamity Contingency Fund (NCCF) and recommending the quantum of assistance to be provided to the states will now be discharged by NEC.

### 1.12.3 National Disaster Response Force

1.12.3.1 The DM Act 2005 has mandated the constitution of the National Disaster Response Force (NDRF) for the purpose of specialised response to a threatening disaster situation or disaster. The general superintendence, direction and control of the force is vested in, and exercised by, NDMA and the command and supervision of this force is vested in the Director General of NDRF. Presently, NDRF comprises eight battalions with further expansion to be considered in due course. Seven of these battalions have been positioned at nine different locations in the country based on the vulnerability profile. This force is being trained and equipped as a multi-disciplinary, multi-skilled, high-tech force with state-of-the-art equipment. To ensure prompt response during any disaster, each of the eight NDRF battalions will have three to four states/UTs as their areas of responsibility. Each battalion will have three to four Regional Response Centres (RRCs) at high vulnerability locations where trained personnel with equipment will be pre-positioned. NDRF units will maintain close liaison with the state administration and be available to them pro-actively, thus avoiding long procedural delays in deployment in the event of any serious threatening disaster situation. Besides, NDRF will also have a pivotal

role in Community Capacity Building and Public Awareness. NDRF is also enjoined with the responsibility of basic training of personnel of the State Disaster Response Force (SDRF), Police, Civil Defence, Home Guards and other stakeholders in disaster response.

### 1.12.4 National Reserves

1.12.4.1 The experience of major disasters in the last decade has clearly established the need for a national initiative for pre-positioning of some essential reserves at crucial locations, including some for high altitude areas. These reserves are intended to augment the resources of the states. These will be co-located with NDRF battalions at nine different locations in the country and released to the states on the recommendation of the NDMA.

### 1.12.5 National Institute of Disaster Management

1.12.5.1 The National Institute of Disaster Management (NIDM) has institutional capacity development as one of its major responsibilities along with training, documentation of research, networking and development of a national level information base. NIDM will function closely within the broad policies and guidelines laid down by NDMA and assist in developing training modules, impart training to trainers and DM officials and strengthening of Administrative Training Institutes (ATIs) in the state. It will also be responsible for synthesising research activities. NIDM will be geared towards emerging as a 'Centre of Excellence' at the national and international levels.

### 1.12.6 State Disaster Management Authority

1.12.6.1 At the state level, the State Disaster Management Authority (SDMA) headed by the Chief Minister, will lay down policies and plans for DM in the state. It will, *inter alia*, approve the state plan in accordance with the guidelines laid down by NDMA,



coordinate the implementation of the state plan, recommend provision of funds for mitigation and preparedness measures and review the developmental plans of the different departments of the state to ensure integration of prevention, preparedness and mitigation measures.

1.12.6.2 The state government will constitute a State Executive Committee (SEC) to assist the SDMA in the performance of its functions. The SEC will be headed by the Chief Secretary to the state government and coordinate and monitor the implementation of the national policy, the national plan and the state plan. It will also provide information to NDMA relating to different aspects of DM.

### 1.12.7 District Disaster Management Authority

1.12.7.1 At the cutting edge level, the District Disaster Management Authority (DDMA) headed by the District Magistrate, with the elected representative of the local authority as the co-chairperson, will act as the planning, coordinating and implementing body for DM and take all necessary measures for the purposes of DM in the district in accordance with the guidelines laid down by NDMA and SDMA. It will, *inter alia*, prepare the district DM plan including the response plan for the district, coordinate and monitor the implementation of the national and state policies, the national, state and district plans and ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by NDMA and SDMA are followed by all departments of the government at the district level and the local authorities in the district.

### 1.12.8 Local Authorities

1.12.8.1 This includes Urban Local Bodies (ULBs), Panchayati Raj Institutions (PRIs), district and Cantonment Boards and Town Planning Authorities for control and management of civic services. These bodies will ensure capacity building of their officers

and employees in DM, carry out relief, rehabilitation and reconstruction activities in the affected areas and will prepare DM plans in consonance with guidelines of NDMA, SDMAs and DDMA.

### 1.12.9 Civil Defence

1.12.9.1 In any disaster, it is the community that is always the first responder. Outside help comes in only later. Training the community and making such response organised is therefore of utmost importance.

1.12.9.2 A revamping of the Civil Defence under this scheme has been proposed in which the Civil Defence will be made district-centric to cover all the districts of the country in two phases. In the first phase, 241 multi hazard districts will be covered. Of these, 37 districts which are cyclone prone, already have a Civil Defence set-up in its major towns.

1.12.9.3 In the meanwhile, the Civil Defence set-up already existing in the country will be immediately utilised to train the community for disaster response in the concerned districts of the already activated towns. The DG, Civil Defence, in their respective states will work out training modules for disaster management covering awareness generation, first aid and rescue drills. Selected Civil Defence personnel will be trained for Chemical, Biological, Radiological and Nuclear (CBRN) emergencies and will be closely involved in assisting all response agencies. Other Civil Defence personnel will support the response agencies for management of CBRN. NIDM will prepare a comprehensive training module simultaneously and circulate it, which will be incorporated in the already ongoing training.

## 1.13 Existing Institutional Arrangements

1.13.1.1 The Cabinet Committee on Management of Natural Calamities (CCMNC) and the Cabinet Committee on Security (CCS).

1.13.1.2 CCMNC has been constituted to oversee all aspects relating to the management of natural calamities, including assessment of the situation and identification of measures and programmes considered necessary to reduce its impact, monitor and suggest long-term measures for the prevention of such calamities formulate and recommend programmes for public awareness for building up society's resilience to them. In specific cases, CCS will also be kept informed of the manner in which these disasters are being managed. NDMA's linkages with these committees will be institutionalised.

### 1.13.2 Role of Central Ministries and Departments

1.13.2.1 As DM is a multi-disciplinary process, all central ministries and departments will have a key role in assisting NDMA in the discharge of its functions. The nodal ministries and departments of the Gol, i.e., the Ministries of Home Affairs, Agriculture, Civil Aviation, Environment and Forests, Health, Atomic Energy, Space, Earth Sciences, Water Resources, Mines, Railways. etc., will continue to address specific disasters as assigned to them. Further, MHA will act as the administrative ministry on the subject of DM.

### 1.13.3 National Crisis Management Committee

1.13.3.1 The National Crisis Management Committee (NCCM), comprising high-level officials of the Gol headed by the Cabinet Secretary, will also deal with specified major crises. It will be supported by the Crisis Management Groups (CMG) of the central nodal ministries. The Secretary, NDMA, will be a member of this Committee.

### 1.13.4 State Governments

1.13.4.1 The primary responsibility for DM rests with the states. The arrangements put in place will

be such as to enable, empower and strengthen the DM apparatus at the state level. Appropriate policy, financial and administrative systems will be established by the state governments. The central government will provide all cooperation and assistance to the state governments in consonance with the gravity of the disaster situation.

1.13.4.2 State governments will take all measures specified in the guidelines laid down by NDMA and extend cooperation and assistance in DM to NDMA and NEC.

### 1.13.5 District Administration

1.13.5.1 At the district level, the District Disaster Management Authorities (DDMAs), which constitute the very bedrock of the entire DM apparatus, will be in charge of DM and will control and coordinate all line departments, i.e., police, fire services and any other form of support system as part of their response. In the planning stage, the Collector/District Magistrate/Deputy Commissioner will head all planning and preparedness exercises pertaining to DM.

### 1.13.6 Management of Disasters Impacting more than One State

1.13.6.1 At times, the impact of disasters occurring in one state may spread over to areas in other states. Similarly, preventive measures in respect of certain disasters, such as floods, etc. may be required to be taken in one state, while the impact of their occurrence may affect another. The administrative hierarchy of the country is organised into the national, state and district level administrations. This presents some difficulties in respect of disasters impacting more than one state. The management of such situations calls for a coordinated approach which can respond to a range of issues quite different from those that normally present themselves before, during and after the event.



## 1.14 National Cyclone Risk Mitigation Project

1.14.1 The Government of India has drawn up the National Cyclone Risk Mitigation Project (NCRMP) to be implemented with World Bank assistance. Initially, the MHA formulated the project that was transferred to NDMA in September 2006. The main aim and objective of the project is to strengthen the structural and non-structural cyclone mitigation efforts and reduce the risk and vulnerability of the coastal districts which are prone to cyclones. NCRMP will assist states/UTs which are prone to cyclones and will go a long way in building capacities for cyclone risk mitigation. This is the first such effort at the national level with World Bank assistance of about US \$300 million, covering 13 coastal states and UTs. NCRMP consists of the following four components:

- i) Component A: Improvement of early warning dissemination system by strengthening Last Mile Connectivity (LMC) of cyclone warnings and advisories from source/district/sub-district levels to community.
- ii) Component B: Cyclone risk mitigation investment which has identified nine sub-components like construction of cyclone shelters, construction of saline embankments, mangrove plantations, shelterbelt plantations, etc.
- iii) Component C: Technical assistance for hazard risk management and capacity building
- iv) Component D: Project management and institutional support

## 1.15 National Guidelines: Genesis, Structure and Implementation Strategy

1.15.1 The paradigm shift in the Government of India's focus from the earlier rescue and relief-centric approach to a holistic approach covering all aspects of DM has been the thrust of this effort to evolve national guidelines for the management of cyclones.

1.15.2 A nine-step process has been followed that includes review of the present status and assessment of critical gaps. This has been done by taking on board the nodal agencies, ministries/ departments of Gol and state governments/UTs, academic, scientific and technical institutions and NGOs, and obtaining exhaustive feedback from district and sub-district levels through interaction with elected representatives, including those from ULBs and PRIs. Mitigation and preparedness aspects of the management of cyclones have been dealt with in other chapters. Other non-structural measures like micro-finance, insurance and re-insurance, etc., have been covered separately.

1.15.3 There are several structural and non-structural measures for effective cyclone DM. The structural measures include construction of cyclone resistant buildings, road links, culverts, bridges, canals, drains, saline embankments, surface water tanks, communication and power transmission networks, etc. Non-structural measures like early warning systems, communication and dissemination, management of coastal zones, awareness generation and disaster risk management and capacity development, have also been dealt with separately.

# 2

## Early Warning Systems

### 2.1 Overview

2.1.1 Natural hazards like hydro-meteorological events occur in all parts of the world, although some regions are more vulnerable than others. Hazards become disasters when people's lives and livelihoods are destroyed. Further, human and material losses caused by disasters are a major obstacle to sustainable development. By developing a system of issuing accurate forecasts and warnings in a form that is readily understood, lives and property can be protected. The WMO coordinates the efforts of national meteorological services to mitigate human and property losses through improved early warning services, risk assessments and to raise public awareness on the risk and vulnerability for TCs.

2.1.2 By 2019, WMO aims at reducing by 50% the 10 year average fatality (observed during the period 1994–2003) for hydro-meteorological disasters. Early warning in the context of cyclones is a short-term mitigation measure. It employs detection of the system, its continuous monitoring, prediction, formulation of warnings, identification of threat areas and population and communication of warning with lead time and clarity so that action is taken by the concerned people to avoid negative consequences. The emphasis is on disaster risk reduction. It is said that one dollar invested in disaster preparedness can prevent seven dollars' worth of disaster-related economic losses which is a considerable return on investment.

2.1.3 Due to the very destructive nature of TCs and their adverse impact on human activities the

world over, considerable attention of scientists and engineers has been drawn towards this subject from early days. As a result, early warning systems for TCs have been developed. In fact, most of the meteorological services, including IMD, had been established towards the middle or later part of the nineteenth century to provide cyclone warnings to sea-faring communities. With advanced science and technology and global efforts, today it is possible to organise dependable cyclone early warning services and minimise the loss of life and property by taking appropriate action on advance warnings resulting in better and improved response.

2.1.4 In order to monitor and forecast cyclones, data is required not only from the ocean where it forms, but also from the entire globe if warnings are to be provided with sufficient lead time. Data is required from the oceans and atmosphere, from accessible and inaccessible places during the day and night at regular intervals.

2.1.5 Climatological data on the frequency and intensity of TCs in the Indian seas that affected India are available for a period of more than 110 years. Frequency analyses have also been carried out to determine the risk on a macro scale (up to the district level). With the available data, hazard parameters have also been analysed by some researchers on a macro scale. But such data is not sufficient for micro-scale (taluka/block/mandal level) analysis. Hence, necessary data needs to be generated for micro-scale analysis by strengthening observation networks based on long-term planning. In the mean time, cyclone risk assessment on a micro scale will be attempted for all the cyclone-affected states

and Union Territories (UTs) of India by considering all the available data.

2.1.6 The most important requirement is the development of robust and reliable operational techniques for forecasting the track, intensity and hazards associated with TCs such as storm surge, strong winds and heavy rainfall based on sound hydrodynamics through numerical models and storm surge modelling. Particular attention needs to be given to the coastal regions taking into account the complex coastal orientation, estuaries—including the massive freshwater discharges from various river systems of the Arabian Sea and the Bay of Bengal in the NIO Basin.

2.1.7 Surge prediction demands accurate surface wind forecasts for several hours before the cyclone landfall. Hence, further development of a suitable meso-scale cyclone model along with generating most representative high resolution (1 km grid scale) surface wind vector field surrounding the cyclone combining meso-scale model fields and all available surface observations from land, ocean and space based platforms is equally important. The total water level is the combined effect of storm surge and astronomical tide. Therefore, accurate prediction of the tidal height in the model is essential. For driving models, reliable real time data of meteorological, hydrological and oceanographic variables are fundamental. The data will be freely available to participating agencies through fail-safe networks, including meteorological satellite data reception facilities and associated telecommunication support infrastructure.

## 2.2 Present Status and Future Strategies

### 2.2.1 Observational Network

2.2.1.1 Cyclones in the NIO Basin are monitored with the help of land-based, ocean-based and space-based observational systems which include

conventional meteorological observations, reports from ships, observations from ocean data buoys, coastal radars (conventional and Doppler) and national and international satellites (geo-stationary and polar orbiting).

2.2.1.2 To facilitate quantification of the likely impact associated with cyclone landfall, land-based observational density will be enhanced beyond IMD's modernisation plan. Table 2.1 overleaf provides the present level of the land-based observational set-up of IMD's enhancements proposed under its modernisation plan and additional augmentation required to be established beyond its modernisation plan.

2.2.1.3 Observations by automatic instruments and quick fail-proof communication of observations to forecasting centres are modern concepts. Doppler Radars are used the world over to detect and monitor localised severe weather systems. Sustainability of the instruments against adverse weather conditions is essential. Adequate density of network is another factor which needs to be looked into during the process of modernisation. Modernisation, augmentation and standardisation of the meteorological observation network maintained by other agencies at the centre and states will assign priority in the modernisation of their network, so that observations are useful and compatible.

IMD will carry out modernisation of its observation network with density augmentation, wherever needed, on a priority basis, covering the 84 cyclone-prone districts in all coastal states and UTs. Central and state government agencies, other than IMD, dealing with meteorological observations will assign priority to the modernisation of the meteorological and hydrological observation network in their domain in these 84 districts.

2.2.1.4 Efforts are to be made for the reception of all available data at the earliest, directly from the

**Table 2.1 Additional Augmentation of Land Based Observational Networks of IMD**

S. No.	Observation Type	Present Status	Proposed Enhancements as Part of IMD's Modernization Plan	Additional Augmentation
1	Automatic Weather Stations	125	1000* -	3000 [Augmentation up to 840 covering 84 districts of cyclone vulnerability in states/ UTs] Minimum of 84 High wind Recorders (1 per district)** Minimum of 84 Surge recorders (1 per district)** [No. of High wind speed recorders and surge recorders need to be increased to 3–5 per district wherever, climatologically, cyclone frequency is higher and has a higher PMSS variability along the coast]
2	Rain Gauges	2579 (Part-time)	4000* (Automatic)	Taluk level Rain Gauge Network
3	Radars (S-Band Doppler) DWR	5	12	-
4	Radars (Storm detection X-Band)	21	26 (C-band Doppler)	-
5	Wind Profilers***	1	45	84 (1 per district)

\* Covering the entire country, including coastal districts.

\*\* To be activated during the High Impact Weather Period

\*\*\* Likely to be provided in airports. Augmentation to cover all coastal districts.

original data generating agencies for their effective utilisation in cyclone warning systems in India.

2.2.1.5 All necessary data reception facilities from the forthcoming satellite payloads such as METSAT, INSAT, OCEANSAT and MEGHATROPIQUES, algorithm development, timely product generation, updated terrain/land use mapping, etc., in respect of each of the future satellites will be put in place by the Department of Space/ IMD in time with the satellite launch so that the respective products can become available for cyclone early warning purposes.

2.2.1.6 Enhancement of Observational Network  
The following enhancements will be carried out in respect of different types of observational network:

**Land-Based Observations**

- Early establishment of planned Automatic Weather Stations (AWS) and Rain-gauge Network.
- Establishment of at least one High Wind Speed Recorder and one surge recorder for each coastal district, vulnerable to cyclones (on priority basis).

- Enhancement of a Doppler Weather Radar Network over coastal regions at an interval of 300 km along the coast
- Augmentation of high resolution vertical soundings with the enhancement of Radio Sonde (RS)/Radio Wind (RW) Network and introduction of Wind Profilers

**Ocean-Based Observations**

- Enhancement of shallow water and deep water buoy network over Indian seas.
- Enhancement of ocean observations involving ships of opportunity, Coast Guard vessels and Indian Naval Ships; off-shore oil platforms and Islands.
- Inclusion of subsurface ocean parameters from space and in situ observations, especially in the mixed layer.

**Space-Based Observations**

- Ensure the operational service of at least two geostationary satellites over Indian seas at any

- given point of time (with water vapour channel and vertical sounder capability as planned in INSAT 3D), especially during cyclone months.
- Generation of high spatial resolution data sets of land-surface parameters on weekly/ bi-weekly basis utilising IRS and other global satellites
- Real time reception of global satellite products, especially from microwave sensors, over Indian seas for operational use through bilateral and multi-lateral arrangements.

**2.2.2 Further Issues to be Addressed**

2.2.2.1 The NDMA Sub-Group on Early Warning Systems (EWS) for cyclone guidelines has identified some more issues to be addressed beyond the IMD’s modernisation plans which are essential to raise our cyclone DM capabilities to international standards. The table below provides the major issues that have been identified, and the efforts to address them.

Issues Identified	Efforts Needed to Address them
1. Lack of critical observations from the cyclone core environment (capable of reduction of forecast errors to the tune of 16–30% in respect of cyclone track and intensity).	Aircraft Probing of Cyclone (APC) Facility
2. Quantification of the likely impact based on improved EWS. The improved EW will be achieved by harnessing the benefits of IMD’s modernisation plans.	Developing centralised lead-time impact assessment
3. Local-scale hazard, risk and vulnerability assessment to help the coastal states/UTs to develop mitigation plans.	Capacity development for the mitigation and risk reduction Planning for holistic cyclone DM
<p><b>Note:</b> i) Issues at 2 and 3 above are in tune with the general recommendations of the Planning Commission’s XIth Plan Working Group on DM</p> <p>ii) While issues 1 and 2 are discussed in this chapter, 3 is discussed in Chapter 7</p>	

### 2.2.3 Aircraft Probing of Cyclone (APC) Facility

2.2.3.1 In the absence of aircraft probing facilities, it has not been possible to obtain realistic initial state three-dimensional description of cyclones in the NIO region. Lack of such critical observations from the cyclone core environment is resulting in large track and intensity forecast errors. The establishment of APC facilities of the cyclone core environment can significantly address this critical data gap in cyclone intensity and track forecasting.

2.2.3.2 Other applications of APC Facility for multi-hazard DM include:

- i) Airborne Doppler Weather Radar for identification of heavy rainfall and strong wind zones (cyclone impact assessment).
- ii) Airborne Laser Terrain Mapping (ALTM) of coastal zones and islands (delineating depth and extent of coastal inundation, hazard mapping and vulnerability assessment).
- iii) Post-cyclone damage assessment and aerial survey (for impact assessment and planning post-disaster relief operations).
- iv) Planning observational campaign for the advancement of R&D efforts in cyclone forewarning (up to 150 days per year, including such cyclonic disturbances formed during the monsoon season, pre-monsoon thunderstorm events in eastern India – *kalbaisakhi* – and the study of other high impact weather phenomena over land).
- v) Aerial mapping/observational facility for multi-hazard impact assessment (floods, earthquakes, landslides, forest fires, chemical accidents, etc.).
- vi) APC facility can also be used for the study of monsoon systems in South Asian countries, research on the effects of climate change and for defence applications as well.

2.2.3.3 The recommendations of the Cyclone Review Committee (CRC), 1984 were revisited. The CRC had fully endorsed the need for establishing APC facilities for observations from the inner core of cyclones. Similar recommendations were made at different workshops organised by NDMA at Hyderabad, Ahmedabad and Delhi, and at the First India Disaster Management Congress held in November 2006.

2.2.3.4 The need for establishing APC facilities was also endorsed by top-ranking officials of NTRO, MoD and DoS at a meeting specially convened by NDMA in December 2006 (see page 154).

APC facility will be set up on high priority. IMD/NRSA will provide the technical control and operational control will be provided by the Indian Air Force (IAF). Day-to-day operational schedules and flight paths will be decided in consultation with user departments such as IMD, Central Water Commission (CWC), etc. Ministry of Earth Sciences (MoES) will initiate all necessary actions for establishing APC facilities.

### 2.2.4 Unmanned Aerial Vehicle

2.2.4.1 A high altitude Unmanned Aerial Vehicle (UAV) can provide detailed observations of the near surface, high wind environment; an area often too dangerous for manned aircraft for taking observations. The first UAV touched down after a 10-hour mission into the tropical storm "Ophelia" on 16 September 2005. This aircraft, known as an Aerosonde, has the potential to emerge as a cost-effective observational platform for the reconnaissance and surveillance of tropical cyclones.

Considering its vast coastline, India will develop and utilize UAV capabilities for surveillance and prediction of TCs. This effort can be coordinated by the IAF and IMD/MoES.

## 2.2.5 Implementation Strategy of Observational Infrastructure

2.2.5.1 It is necessary to organise the efforts required for generating real time observational data for cyclone Early Warning (EW) from various government departments and agencies at the

national and state levels. In order to ensure timely collection and accessibility of data for its utilisation with regard to cyclone EW, specific tasks are to be carried out by various nodal agencies assigned with specific responsibilities as per the existing arrangements and further augmentation of responsibilities. These are shown in Table 2.2 below.

**Table 2.2 Real time Observational Data for Cyclone EW**

S. No.	Type of Observation	Nodal Ministry	Nodal Agency	Agencies to be Involved
1	Land-based Observations	Ministry of Earth Sciences	IMD	IAF, Indian Navy, DoS, CWC, State Irrigation Departments, Agricultural Universities, River Authorities, etc.
2	Ocean-based Observations	Ministry of Earth Sciences	INCOIS	National Institute of Ocean Technology (NIOT), Indian Navy, Coast Guard, Ships of opportunity, International Floating Platforms, etc.
3	Space-based Observations	Department of Space	ISRO	IMD, International satellite agencies from polar orbital and geostationary platforms
4	Special Observations	Ministry of Earth Sciences/ Department of Space	IMD/NRSA	IAF, CWC and other user agencies

2.2.5.2 The designated agencies shown in Table 2.2 will be responsible for coordinating efforts to collect the required data in collaboration with other agencies. Comprehensive quality control and data assimilation of the combined data set will be carried out by the respective agencies for generating most representative cyclone specific, high resolution data sets for numerical weather prediction models. These analysed cyclone data sets, along with observational data, will be made available to the various agencies involved in operational/R&D efforts in cyclone EW, mitigation and risk management activities.

## 2.2.6 Forecasting of Tropical Cyclones

2.2.6.1 The track forecast of TCs is prepared with the help of track forecast models of different types, including numerical techniques. Currently, IMD uses a limited run of the quasi-lagrangian dynamic model for track prediction along with other synoptic, climatological and empirical techniques. Intensity forecasts are made by using satellite techniques. For prediction of storm surge, different dynamical techniques are used. The forecast advisories received from different international agencies such as the Joint Typhoon Warning Centre (JTWC), Pearl Harbour, USA; United Kingdom Meteorological Office (UKMO); European



Centre for Medium Range Weather Forecasting (ECMWF); and National Centre for Medium-Range Weather Forecasting (NCMRWF) are also considered while finalising the forecast. The current accuracy of track forecast is about  $\pm 140$  km for a 24 hour forecast and  $\pm 250$  km for a 48-hour forecast. The error increases with increase in the duration of the forecast projection. This translates into warnings covering very large areas if issued more than 24 hours ahead. This limits the lead time of the warning to 24 hours. The accuracy of these forecasts need to be improved significantly. Globally, with the use of multi-ensemble and meso-scale models, accuracy in the range of  $\pm 60$ – $80$  km for a 24-hour forecast has been achieved.

Track and intensity forecasts will be improved by using state-of-the-art, multi-layer meso-scale models with real time inputs of data from satellites and ground-based radar systems.

2.2.6.2 IMD will lead the concentrated national effort to achieve improvements involving:

- i) Selection of a suitable model and establishing a system of generating the most representative initial state 3-D atmospheric fields with the implementation of an appropriate data assimilation system for satellite data inputs (scatterometer winds, high resolution satellite derived winds, satellite derived temperature and moisture fields, etc.);
- ii) Track prediction using several advanced techniques, including the super ensemble method;
- iii) Extensive validation using data of several past cyclones, and
- iv) Developing institutional interfaces with IMD, NCMRWF, CWC, NRSA and other agencies/institutions.

## 2.2.7 Real time Data Reception, Processing and Assimilation Capabilities

2.2.7.1 To generate a most representative 3-D structure of the atmosphere for forcing cyclone forecast models, the following are to be carried out:

- i) All the observational data from various heterogeneous platforms will be collected and transmitted to operational forecast centres for their utilisation in improving cyclone warning efforts.
- ii) Appropriate automated data processing and quality control algorithms will be developed by agencies like IMD, NCMRWF and research institutes connected with meteorological data processing and forecasts.
- iii) Improved high resolution meso-scale data assimilation systems involving 3-D and 4-D variational assimilation techniques will be developed.
- iv) Cyclone specific, most representative, initial state and boundary fields will be generated.

## 2.2.8 Multi-Model Track, Intensity Hazards and Landfall Prediction

2.2.8.1 Following are some of the important recommendations for the improvement of track, intensity hazard and landfall forecast:

- i) Improvement of global, regional and meso-scale modelling systems for prediction of the track, intensity and landfall of cyclones,
- ii) Development of a coupled ocean-atmospheric meso-scale model for the prediction of genesis, intensification of TCs over seas and prediction of storm surges, inland inundation and ocean waves,



- iii) Real time reception of cyclone forecast fields from other leading global centres (US Weather Service, UKMO, ECMWF, Japan Meteorological Agency (JMA), etc.) to use in the objective assessment of striking potential and heavy rainfall forecasts.

### 2.2.9 Historical Digital Cyclone Track Database

2.2.9.1 Accurate determination of TC landfall, location and timing is the key to the effectiveness of TC warnings/forecasts for a specific region. The relevance and availability of best cyclone track data for economic analysis is of particular importance to risk models that estimate the probability of future losses from TCs. Based on this basic information, it is possible to produce normalised databases for losses and damage estimates from natural disasters and for predicting the probabilities and costs of future events based on changes of the vulnerability profile itself.

Historical track data with details like position, intensity (wind and sea level pressure), size, radius of maximum wind and landfall parameters will be archived in digital form and this data will be made available to users/institutions.

### 2.2.10 Appropriate Modelling Framework

2.2.10.1 Forecasting of land-falling TCs with a lead-time of 48–72 hours is important. Some coastal areas have developed to such an extent that more than 12 hours are needed for organizing emergency response preparations. Although track forecasting has improved dramatically for longer time periods, further improvements are required. This becomes imperative as population increases rapidly in many cyclone prone coastal areas.

2.2.10.2 Advancement in operational TC intensity prediction is lagging behind improvement in TC track forecasting. In this regard, the use of the satellite

scatterometer data (e.g. QuickSCAT, SSM/I, TMI) has the potential for providing a Dvorak-like intensity estimation technique. Forecasters will benefit from these latest developments by cross-checking available wind distributions with the synoptic observations and satellite/radar images while estimating the TC intensity. Effective assimilation of the QuickSCAT and SSM/I wind data as well as other remotely sensed data into Numerical Weather Prediction (NWP) will help to improve the TC track and intensity forecast by with the use of numerical models.

IMD will ensure real time reception of the satellite scatterometer data, wind fields from TMI and SSM/I sources as their assimilation into the NWP model is essential for improving forecast accuracy.

2.2.10.3 Ensemble forecasting techniques are being increasingly used in TC track prediction in recent years. The single model ensemble approach defines perturbed initial conditions that represent the uncertainty in the analysis and then integrates the ensemble members with a single model, and verifications show that the multiple model ensemble approach results in noticeable improvement in TC track forecast errors. Recent research suggests that a TC track forecasting system can be developed to assist forecasters in selecting the best performing NWP models to construct the ensemble forecast on each occasion.

IMD will introduce multi-model ensemble forecast techniques for operational cyclone warnings.

## 2.3 Prediction of Severe Weather and Storm Surges

2.3.1 To predict the time of onset of severe weather and storm surges at specific locations, detailed knowledge of the wind and precipitation structure of the TC (e.g., TC size, gale wind radius) have to be known besides the forecast track. Observations in recent years from advanced

sensors (e.g., Tropical Rainfall Measuring Mission (TRMM), Special Sensor Microwave/Imager (SSM/I), Advanced Microwave Sounding Unit (AMSU), and (QuickSCAT) on the new generation of meteorological satellites have greatly enhanced our knowledge on the structural characteristics of wind and precipitation fields associated with cyclones.

2.3.2 Valuable and critical information on wind fields can only be obtained from GPS dropsondes and Stepped Frequency Microwave Radiometers from aircraft reconnaissance. The Doppler Weather Radar is an important equipment in terms of obtaining very high resolution wind and rainfall distribution of land-falling TCs. Correlation and extrapolation techniques have been usefully employed to depict the wind structure of TCs and to make very short-range rainfall forecasts.

2.3.3 IMD has been using locally developed nomograms and a PC-based storm surge model developed by the Indian Institute of Technology, Delhi, for storm surge prediction at the time of TC landfall without having any means of generating spatial inundation of surge waters. Recently, under the World Bank funded Andhra Pradesh Hazard Mitigation and Emergency Cyclone Recovery Project (APHM and ECRP), a tailor-made framework model of storm surge and wind damage, along with GIS based Decision Support Systems (DSS) has been developed to demarcate the extent, duration and depth of inundation scenarios and quantifiable damages to houses, crops, power/communication towers, roads/culverts, etc.

Storm surge modelling efforts for generating spatial inundation and wind damage over the land will be developed and incorporated in the operational system with priority.

## 2.4 Cyclone Forecasting and Emergency Management Networks

2.4.1 Some countries have set up dedicated video/audio facilities and websites to communicate

with other emergency organisations and technical groups. A consensus assessment of the cyclone forecast is arrived at through broad based consultation and coordination.

2.4.2 Weather information is being accessed by general public—ranging from highly intelligent and knowledgeable people to weather illiterate individuals. At the intelligent and highly weather-literate end of the spectrum, there is greater demand for real time meteorological data relevant to current weather conditions (e.g., winds, rain and temperatures). Many weather services now make available information from automatic weather stations (AWS) on their websites. Some put radar images on their websites as well, which has been found to strengthen the credibility of the services. This is being done in India as well by IMD. Some emergency services as well as operators of public utilities such as airports, ferries, buses and trains would like to be given advance alert prior to community-wide dissemination of TC warnings, even if it is as short as a few minutes. This allows them to organise and/or mobilize necessary response resources before the public actually reacts to the warnings. This is particularly useful when the public's reaction to a warning translates immediately into increased demand on public services.

2.4.3 Besides, traditional synoptic observations and TC warning advisories, global operational agencies [National Centre for Environmental Prediction (NCEP), UKMO, ECMWF, JMA, etc.] and major global research institutes have put much effort in sharing Numerical Weather Prediction products 'best track' databases, radar images and satellite images as well as scatterometer data over the Internet in recent years.

## 2.5 Parametric Wind Field and Cyclone Risk Models

2.5.1 Parametric wind models form the basis of the TC hazard component of many risk models.

The next-generation parametric wind model would provide a more realistic wind field and improve the TC hazard component of a risk model, which can lead to and thereby improve loss and cost estimates associated with TC landfall. Recent wind field observations collected with Global Positioning System (GPS) dropsondes have many characteristics that are not represented by standard parametric models.

2.5.2 Risk models are made of four basic components: a hazard component, vulnerability component, a damage component, and a loss component. The hazard component provides the probabilities and characteristics of a specific hazard. For a TC, it would provide information such as nature of storm track at landfall, forward motion, wind field and decay over land. The vulnerability component provides information about the impact on structures and human population considering several factors. The damage component of the risk model uses this information to calculate the expected damage and the loss component estimates the costs associated with rebuilding, loss of business and liabilities. Best-track data are also used to define probability distributions for characteristics of TCs (e.g., forward motion and intensity) in a risk model. Additional storm characteristics such as the radius of maximum winds, maximum gusts and rainfall would improve the depiction of TCs by the hazard component of a risk model and lead to a more realistic estimate of future losses and costs and improve estimates of the benefits of mitigation efforts.

## 2.6 Implementation of Impact Assessment and Emergency Response Management System

2.6.1 Based on the analysis carried out above, it will be appropriate to consider establishing a suitable institutional framework in the form of an institute at national level (discussed in detail in section 7.14) so that all the developmental objectives

required for total cyclone risk management at the local level can be achieved. Further, to supplement this endeavour, efforts discussed earlier to procure a specially instrumented Reconnaissance Aircraft and UAVs for collecting spatial observations from the core cyclone environment are to be organised for facilitating improved cyclone EW. Such a facility has been the longstanding demand of the scientific community in India. Such a direction figures in the recommendations of the Scientific Advisory Committee to the Cabinet (SACC) in December 1984 and the Reports of Recommendations of CRC (Volumes I, II and, III) for implementation by various central and state government agencies.

2.6.2 Multi-model cyclone forecast products from various sources (national and international weather centres) are to be considered for framing operational cyclone warning and, accordingly, respective state/UT authorities will take all necessary emergency response and mitigation activities to deal with the disaster effectively. Such a mechanism is working very successfully in many advanced countries. Similar capabilities in this country can also be attained by the adoption of a suitable framework of hazard mitigation modelling, GIS-based Spatial Decision Support Systems (SDSS), well defined communication protocols for various emergency responder groups both at the government and community levels, stating well defined responsibilities of the participating agencies.

## 2.7 Research Issues

### 2.7.1 Very Short-range Forecasting

The critical period for some places is 6–12 hours before TC landfall. In such a short time-frame, NWP guidance cannot offer much assistance to forecasters. Very often, forecasters have to subjectively now-cast the TC movement in the next 6–12 hours based on radar images and limited synoptic/AWS data. Any abrupt change in the direction of movement and/or looping motion of these TCs near the coast poses much difficulty in

forecasting the landfall location and timing. Therefore, movement of the TC prior to landfall has an important bearing on the formulation of an effective warning and emergency response strategy.

Research initiatives to improve the capability of forecasters in very short-range forecasting of land-falling TCs are essential and will be carried out by IMD and other institutions dealing with the subject.

2.7.2 Developments in data assimilation and numerical models will continue independent of the TC forecast problem. Ongoing improvements to 3D and 4D variational assimilation methods with the inclusion of new data sources and the use of physical initialisation procedures will continue to produce improvement in the definition of the large-scale environment and outer structure of TCs (and hence in track forecasts). For those basins (tropical part of US Atlantic and Pacific) that are fortunate enough to have aircraft reconnaissance, availability of dropsonde data and eventually advanced NWP targeting strategies will result in further significant improvement in track forecasting. The question of vortex specification synthetically remains open. Its use is possibly dependent on the application. For short-term track and intensity forecasts, it would seem necessary in the near future. Careful diagnosis of its impact on short- to medium-range prediction will be undertaken. With increase in resolution, the question also arises of how much real TC structure can or needs to be represented in initial conditions.

The issue of vortex initialisation will be investigated, particularly for intense TCs.

2.7.3 With continuous improvement in numerical guidance on track, there appears to have been a slight reduction in basic research on TC motion. The problem of these environmental interactions, erratic tracks such as looping, stalling or rapidly accelerating cyclones and recurving are generally unpredictable and much research is needed to

tackle these issues. For short-term track forecasts, it is possible to improve the details in forecasts via improved meso-scale assimilation techniques (3D, 4D variational assimilation) that take advantage of the latest observational data sets with high spatial and temporal resolution, e.g., scatterometer, radar, rain rate and remotely sensed data. At these high resolutions, initialisation and performance of physical parameterisations become significant research issues in themselves. The effect of surrounding meso-scale convective systems (MCSs) and convective asymmetries on TC motion is mostly unexplained. Now that models can generally handle the 'smooth' motion of TCs, is it possible to predict details in the tracks that might be related to such meso-scale features in the environment? For short-term, high-resolution prediction, will attempts be made to simulate eye-wall cycles and their potential effect on small-scale track deviations? Questions relating to storm track, structure, rainfall and landfall are yet to be answered to the level of satisfaction. Further work is needed to determine how to initialise circulation in such circumstances and to understand the interaction between the storm's circulation and the underlying ocean surface and feedback mechanism. Advanced atmosphere-ocean-land assimilation-prediction systems need to be employed.

2.7.4 For further improvements in short-term forecast, a major issue will be meso-scale data analysis and initialisation, eventually within a coupled atmosphere-ocean-land system. Defining details in storm structure and meso-scale aspects of the storm's environment is a challenging task. It will no doubt require very high resolution, use of some of the data sets previously mentioned, and in the short-term, the use of a synthetic vortex. At high resolution and for intense circulations, other significant issues are initialisation and the performance of physical parameters.

2.7.5 Research support is required to be improved dramatically in India with regard to the

skill of both track and intensity forecasting of TCs. Satellite radiometry and scatterometry data have the potential to improve TC track and intensity forecasting, provided they are suitably employed in hazard modelling and now-casting systems that IMD will address these aspects in its modernisation plan.

### 2.7.6 Developing Centralised Lead-Time Impact Assessment

2.7.6.1 It is established world over that science and technology options offer examples of good practices in terms of demonstrable disaster risk reduction that can be built into ongoing development planning policies both in terms of long-term mitigation/risk reduction and short-term mitigation measures (monitoring, EW, impact assessment and customised warning dissemination protocol). Further, the necessary steps needed for early implementation are to be organised by establishing necessary institutional support for holistic cyclone risk management beyond the early warning. These include damage assessment spatial scenarios of local-scale storm surge inundation, wind damage to lifeline infrastructure, crops, houses, appropriate mitigation strategies, and the development of DSS with tailor-made warning dissemination protocols to DM authorities.

## 2.8 Cyclone Warning Generation

2.8.1.1 IMD is the nodal agency in India for providing cyclone warnings through its Area Cyclone Warning Centres (ACWCs) at Kolkata, Chennai and Mumbai and the Cyclone Warning Centres<sup>1</sup> (CWCs) at Visakhapatnam, Bhubaneshwar and Ahmedabad. The cyclone warning process is coordinated by the office of the Deputy Director General of Meteorology (Weather Forecasting) at Pune and office of Deputy Director General (Cyclone Warning) in the cyclone warning division of the Northern Hemispheric Analysis Centre (NHAC) at

New Delhi. Considering the capability of cyclone warning and the facilities available there, NHAC at New Delhi has been designated as a Regional Specialised Meteorological Centre (RSMC) for TCs. It is one of six such centres in the world; the others being RSMC–Miami, RSMC–Honolulu (USA), RSMC–Tokyo (Japan), RSMC–St. Denis (La-reunion), and RSMC–Nadi (Fiji), recognised by WMO under a global system of cyclone warnings. WMO coordinates cyclone warning activities globally to standardise the system and to bring about improvements. As an international commitment through the WMO/ESCAP (Economic and Social Commission for Asia and Pacific) Panel on TCs, TC advisories are issued by RSMC, New Delhi, to ESCAP panel member countries during TCs in the Bay of Bengal and the Arabian Sea. The three-hourly advisory messages are issued eight times a day. The ESCAP Panel countries are Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand.

2.8.1.2 Doordarshan and All India Radio (AIR) stations at New Delhi are provided cyclone warning information by RSMC–New Delhi for inclusion in the national broadcast/telecast. Information on cyclone warnings is furnished on a real time basis to the Control Room in the MHA, Government of India and NDMA, besides other ministries and departments of the Government and to the cyclone-prone state governments.

2.8.1.3 User specific warnings are issued to commercial shipping lines, the merchant navy, ports, Fisheries Departments and fishermen, government agencies, all transportation services (land, ocean and air), farmers, others specially registered with IMD, AIR, Doordharshan and other TV channels, print media and the general public.

### 2.8.2 Existing Four-stage Warning System

2.8.2.1 A four-stage cyclone warning system was introduced in IMD from the pre-monsoon season of

1999, replacing the previous two-stage warning system:

- i) First, a special bulletin called **Pre-Cyclone Watch** is issued containing early potential indications about the development of a cyclonic disturbance in the NIO region, its possible development into a cyclone and adverse weather that specific areas of the coastal belt are likely to experience. Additional warnings in respect of fisheries and ports are issued to enable the respective authorities to take necessary precautionary steps.
- ii) At the second stage, a **Cyclone Alert** message is issued 48 hours prior to the expected time of commencement of adverse weather over the specific coastal areas.

- iii) A **Cyclone Warning** is issued 24 hours in advance of the cyclone’s landfall in order to cover the devastating impact of cyclones over inland areas.
- iv) Finally, a **Post Landfall Outlook** is issued 12 hours before the landfall and continues till such time as cyclone force gusty winds are expected to prevail over the interior areas.

### 2.8.3 Increased stages and Frequency of Warnings—Seven Stage Warning System

2.8.3.1 There is a need for increasing the frequency and lead-time of warnings covering the pre- and post-cyclone landfall phases. The targeted requirements for improvement of the system are listed in Table 2.3.

**Table 2.3 Targeted Requirements for Increasing Frequency of Warnings**

Sl. No.	Requirements for Triggering Various Actions	Advanced Warning	Warning Frequency	Methodology
1	5–3 days in advance (IMD, NEC/MHA, SECs).	Genesis and Cyclone Watch.	12 hourly	Global and Regional Models.
2	3 days in advance (IMD, NEC/MHA, SECs, DDMAAs).	Cyclone Alert and Clear Stage of Intensification, including possible track.	6 hourly	Regional and Meso-scale Models.
3	2 days in advance (IMD, NEC /MHA, SECs, DDMAAs). Special Observations, including aircraft probing data. Emergency Response Planning.	Track, intensity, Landfall Location and associated coastal lead time hazard impact (storm surge, wind damage, inundation mapping).	3–6 hourly	Meso-scale Models with coupled ocean and wave models. Hazard Mitigation Models and DSSs Tracking by satellites.



4	<p>24 hours in advance (IMD, NEC/MHA, SECs, DDMA)s).</p> <p>Special Observations, including aircraft probed data.</p> <p>Emergency Response Planning Relief Routing and Rehabilitation Planning (Govt., national/state DRFs, CDTs).</p>	<p>Updated Track, intensity, Landfall Location and associated coastal lead time hazard impact (storm surge, wind damage, inundation mapping).</p>	1–3 hourly	<p>Meso-scale Models with coupled ocean and wave models.</p> <p>Hazard Mitigation Models and DSSs Tracking by DWRs.</p>
5	<p>1-12 hrs in advance (IMD, NEC/MHA; SECs, DDMA)s).</p> <p>Special Observations including aircraft probing data.</p> <p>Emergency Response Planning.</p> <p>Relief Routing and Rehabilitation Planning (Govt., national/state DRFs, CDTs, NGOs, Local Authority).</p>	<p>Specific updates on intensity, landfall and associated coastal lead time hazard impact (storm surge; wind damage; inundation, etc.).</p>	hourly	<p>Local scale Models (Dynamical-Statistical Approach).</p> <p>Now casting Hazard Mitigation Models and DSSs.</p>
6	<p>Landfall and Post - Landfall up to 24 hrs later.</p> <p>(IMD, NEC/MHA; SECs, DDMA)s).</p> <p>Emergency Response Planning.</p> <p>Relief Routing and Rehabilitation Planning (Govt., national/state DRFs, CDTs, NGOs, Local Authority).</p>	<p>Location specific Intense rainfall, wind, coastal river discharge inundation (including wave and tidal effects) and hazard impact.</p>	1-3 hourly	<p>Local scale observations/ Modelling and DSSs.</p> <p>Aerial Survey over affected areas</p> <p>Satellite/Aerial Mapping for damage assessment.</p>

<b>7</b>	<b>Post-Disaster (2-7 days)</b>	<b>Location specific forecast for relief and rehabilitation efforts.</b>	<b>12 hourly</b>	<b>Local scale observations/ Modelling and DSSs. Aerial Survey over affected areas Satellite/Aerial Mapping for damage assessment.</b>
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DRF—Disaster Response Force; CDT—Civil Defence Teams

#### 2.8.4 Generation of Customised Cyclone Warning

- i) Central Agencies
  - a) Participation of operational agencies (IMD, NCMRWF, Indian Air Force, Indian Coast Guard, Navy, CWC, Prasar Bharati), research scientists, the Central Relief Commissioner and media personnel in the preparation of sector-specific multi-lingual cyclone warning.
- ii) State-Level Agencies
  - a) Evolving appropriate institutional arrangements involving offices of IMD (State Meteorological Centres), SDMA, DM Commissioner, CWC and other line departments for sectoral customisation of cyclone impact in respect of protecting their infrastructure.
  - b) Preparation of user friendly warnings in local language for facilitating community based response.

- i) Adaptation of fail-proof data reception infrastructure
- ii) Adaptation of high-end computing, visualisation and networking infrastructure

#### 2.9.2 Fail-Proof Data Communication Infrastructure for Exchange of Meteorological Data and Warnings (within Metrological services—National and International)

2.9.2.1 The Global Telecommunication System (GTS) for transmission and reception of weather and climate data and forecast products between meteorological offices nationally and internationally consists of an integrated network of point-to-point circuits and multi-point circuits which interconnect meteorological telecommunication centres (MTCs). The circuits of the GTS are composed of a combination of terrestrial and satellite telecommunication links. MTCs are responsible for receiving data and relaying it selectively on GTS circuits. GTS is organised on a three-level basis, namely:

#### 2.9 Requirement of Additional Support Infrastructure

2.9.1.1 The effort involves additional support infrastructure to be commissioned for implementing state-of-the-art cyclone EW and Lead Time Impact Assessment Systems as following:

- i) The Main Telecommunication Network (MTN).
- ii) The Regional Meteorological Telecommunication Networks (RMTNs).
- iii) The National Meteorological Telecommunication Networks (NMTNs).



The regional telecommunication hubs (RTHs) on the MTN perform an interface function between RMTNs and MTN.

2.9.2.2 MTN is the core network of GTS. It links together three world meteorological centres and fifteen RTHs.

2.9.2.3 The first component of the Satellite Communication System is the Area Forecast System (AFS) which supports civil aviation and the second component is the GTS satellite data exchange system for the WMO Region II (Asia) data exchange. They jointly comprise the first component of the overall system. This component distributes grid products and generates observational and worded forecast messages. These products are received from other communication centres or are built at the gateway. They are distributed on multiple data streams of the International Satellite Communication System (ISCS). The data is transmitted using the X.25 protocol from the RTH/AFC to the communication service provider and up-linked via a satellite facility.

IMD will establish Satellite Communication Systems (SCS) on priority for meteorological data reception and delivery with redundant bandwidth at par with other global weather centres.

### 2.9.3 Adaptation of high-end Computing, Visualisation and Networking Infrastructure

2.9.3.1 High-end computing research applications harness the raw speed and data storage capacity of advanced computing platforms to science's most data-intensive, complex, and challenging problems like Earth and Space Science; cyclone track and intensity prediction, and the impact of global warming and changing climate.

2.9.3.2 Advances in the fields of Internet and mobile communication technology have proved to

have significant impact on warning dissemination and information exchange in several countries. As regards warning generation and external liaison, India has to consciously shift from a predominantly science-centred approach to a more user-oriented and customised one to suit local needs of various sectors (infrastructure, socio-economic, natural resources).

2.9.3.3 Nurturing partnerships with the media and local DM (SDMAs/DDMAs) will become an integral part of this imminent change in our strategy and it would require seamless interface with NDMA. The planned high-end computing and networking Infrastructure with nodes in various coastal states/ UTs will take care of this requirement.

2.9.3.4 The Virtual Reality (VR) infrastructure generally consists of an extensive range of computers, projection systems and interaction devices. High-end VR systems can be set up by a personal computer cluster driven by Linux and a five-sided projection system. In the low-end domain, PCs and smaller UNIX workstations from several producers can be configured for use in combination with projection tables or simple monitors and stereo glasses. Special care is to be taken to ensure the software infrastructure to be platform independent, supporting all possible heterogeneity in terms of operating systems like IRIX, HP UX, Sun Solaris, Linux, Windows 2000/XP/Vista. By this strategy, a high scalability to follow the trend in the near future of even complex VR applications will become feasible on low-cost systems with standard PC components.

2.9.3.5 Computing environments and toolkits that are critical for VR environment include architecture adaptive computing environment (aCe), Kernel lattice parallelism (KeLP), Parallel algorithms and software for irregular scientific applications, Advanced Computational Testing and Simulation (ACTS) toolkit, scalable visualization toolkits and tools to explore geometric complexity.

High-end Computing (scalable 30-50 Teraflops peak performance), Storage (800 Terabytes) and Communication Network (Gigabit Ethernet) Infrastructure will be commissioned as a part of the National Cyclone Disaster Management Institute (NCDMI) with seamless connectivity with NDMA, SDMAs of coastal states/UTs and DDMA of 84 coastal districts vulnerable to cyclones. Such a facility will also support additional capacity enhancements (hazard, risk and vulnerability studies) planned for holistic cyclone risk management in states and districts.

2.9.3.6 The planned high-end computing and networking infrastructure with nodes in various coastal states/UTs would take care of the seamless access of local scale spatial and non-spatial data sets for customisation and dissemination of various sector specific hazard maps over a fail safe communication backbone between NDMA and SDMAs/DDMAs. Establishment of the proposed national-level institutional communication framework under the National Disaster Communication Infrastructure (NDCI) and cyclone risk management capacities under NCDMI would enable addressing all the state-level issues related with cyclone risk mitigation in a holistic manner.

#### 2.9.4 Economic Database for Cost-Benefit Analysis

2.9.4.1 The development of a database on the economic losses and costs associated with TC landfall would allow the losses and costs to be normalised for changes in population, wealth and inflation in the affected areas. To maximise the usefulness of the data for cost-benefit analysis, the data will include the expenses associated with TC warning and information services and mitigation efforts as well.

An appropriate system will be established for quantifying and evaluating the returns on investments pertaining to mitigation projects on a regular basis by the central and coastal state governments/UTs.

## 2.10 Suggested Common and Differentiated Activities

### 2.10.1 Role of Central Agencies

- i) Enhancement of observational network.
- ii) Real time data collection and transmission.
- iii) Cyclone specific data processing and assimilation.
- iv) Use of multiple models for track, intensity and landfall prediction.
- v) Objective assessment of striking potential based on decision support systems.
- vi) Multi-sectoral/multi-lingual warning customisation in a user-friendly mode for various stakeholders.

### 2.10.2 Role of State-Level Agencies

- i) Collection and archival of region specific observations.
- ii) Development of customised spatial and non-spatial data sets at the smallest village and taluka level (involving Survey of India and DoS).
- iii) Development of appropriate tools for local-scale impact assessment based on landfall and intensity forecasts obtained from central agencies.
- iv) Development of fully customised hazard maps in respect of various attributes (viz. houses, infrastructure, crops, power transmission/communication network, roads and bridges, etc.) for planning appropriate strategies by respective administrative authorities.
- v) Generation of multi-sectoral customised warnings in the local languages for community level response.
- vi) Disaggregated demographic data for vulnerable sections (elderly, infants and disabled).

## 2.11 Major Action Points

1. Improvement of the existing meteorological observational and communication network with additional augmentation will be carried out on a priority basis. Augmentation and modernisation of rain gauge network tide gauges, etc. will also be carried out. State governments as well as some central government departments [Indian Air Force, Indian Navy, DoS, CWC, Indian Council of Agricultural Research (ICAR)] will give priority to the modernisation of meteorological networks in their domain. Historical cyclone track data with details like position, intensity, size, wind, pressure and temperature, radius of maximum wind and landfall parameters will be archived in digital form and data needs will be made available to users/institutions (refer sections 2.2.1, 2.2.9).  
[Action: MoES, MoWR, DoS, IAF, Indian Navy, Coastal States/UTs]
2. Operational service of at least two geostationary satellites over Indian seas at any given point of time will be ensured (with water vapour channel and vertical sounder capability as planned in INSAT 3D). High resolution spatial data sets of land-surface parameters will be generated on a weekly/bi-weekly basis utilising IRS and other global satellites. Arrangements will be made for real time reception of global satellite products, especially from microwave sensors, over Indian seas for operational use through bilateral and multi-lateral cooperation. All observations from various heterogeneous platforms (from land, ocean and space) will be collected from the original global data sources and transmitted to operational agencies for improved cyclone warning (refer sections 2.2.1.4 to 2.2.1.6).  
[Action: DoS, MoES]
3. Arrangements for Special Observations from the Cyclone Core Environment
  - i) MoES is made responsible for commissioning the APC facility for the country with the support activities steered by NDMA.
  - ii) IAF to provide necessary command control, operations and maintenance support of APC facilities and IMD and other user agencies to lead the planning of flight schedules for probing the cyclone environment (refer sections 2.2.3, 2.2.5).
4. Action will be taken by various nodal agencies to ensure timely collection and accessibility of data for its utilisation in cyclone early warning as per Table 2.4 overleaf.
5. Comprehensive quality control and data assimilation of the combined data set will be carried out by identified agencies for generating most representative cyclone specific high resolution data sets for numerical weather prediction models. Research initiatives to improve the capability of forecasters in very short-range forecasting of land-falling TCs are very essential. Analysed cyclone specific data sets along with observational data will be made available to various agencies involved in operational/R&D efforts in cyclone EW, mitigation and risk management activities (refer sections 2.2.5.2, 2.2.7, 2.7.1).  
[Action: MoES/IMD with Academic and Research institutions].
6. Cyclone specific most representative initial state and boundary fields will be generated through appropriate automated data processing and quality control algorithms and by development of improved high resolution meso-scale data assimilation systems involving 3D and 4D Variational Assimilation Techniques (refer sections 2.2.6, 2.2.7, 2.2.10 ).  
[Action: MoES with research and academic institutions]

**Table 2.4 Nodal Agencies for Collection of Data related to Early Warning**

S. No.	Type of Observation	Nodal Ministry	Nodal Agency	Agencies to be Involved
1	Land-based Observations	Ministry of Earth Sciences	IMD	IAF, Indian Navy, DoS, CWC, State Irrigation Departments, Agricultural Universities, River Authorities, etc.
2	Ocean-based Observations	Ministry of Earth Sciences	INCOIS	NIOT, Indian Navy, Coast Guard, Ships of opportunity, International Floating Platforms, etc.
3	Space-based Observations	Department of Space	ISRO	IMD, International satellite agencies from polar orbital and geostationary platforms
4	Special Observations	Ministry of Earth Sciences/ Department of Space	IMD/NRSA	IAF, CWC and other user agencies

(Refer section: 2.2.5) [Action: IMD, INCOIS, ISRO, NRSA]

- Multi-model cyclone track, intensity and landfall prediction models (global, regional, meso-scale and coupled ocean-atmospheric models) will be developed (refer sections 2.2.8, 2.2.10.3).

[Action: MoES with research and academic institutions]

- Facility for building centralised cyclone impact assessment for quantification of likely impact based on state-of-the-art Cyclone EW by fully harnessing the benefits of IMD’s modernisation plan will be established. Storm surge and wind damage modelling efforts including inundation and impact over the land will be developed and incorporated in the operational system with priority (refer sections 2.4, 2.5, 2.7.6).

[Action: MoEs, MoWR, State Remote Sensing Agency (SRSAs), DM Depts.]

- State-level technical capacities will be enhanced to develop local-scale cyclone impact assessment tools for hazard mapping of wind damage and storm surge

inundation. Such a capability at the state level will help in appropriate development planning for cyclone risk mitigation and emergency response and preparedness planning. All coastal states and UTs will work with the appropriate central government ministries in collection, transmission and archiving of regional scale observations. States will also work with Survey of India (SoI) and DoS towards developing spatial and non-spatial data sets at the micro level in support of cyclone vulnerability mapping (refer sections 2.5, 2.6).

[Action: Survey of India, DoS, MoEs, states/UTs]

- Efforts by central and state government agencies for generating customised sector specific multi-lingual cyclone warning for facilitating community based emergency response will be institutionalised on priority (refer section 2.8.4, 2.10).

[Action: SDMAs, NGOs, Civil Defence Groups etc.]

11. Satellite Communication System (SCS) for meteorological data reception and delivery with redundant bandwidth at par with other global weather centres will be established on priority. All necessary data reception facilities, algorithm development, timely product generation, etc., in respect of each of the future satellites will be put in place in time with the satellite launch so that the respective products can become available for cyclone early warning purposes (refer section 2.9.2).  
[Action: DoS, MoES]

## 2.12 Implementation Strategy and Time-Frame

### 2.12.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

2.12.2 Following is the time-frame for implementation of activities listed in this chapter:

#### Time-frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commence-ment	Action and Date of Completion
1	IMD's observational network modernisation in coastal states/UTs	MoES	2008–09	2011–12
2	Centralised observational data collection from land, ocean and space	MoES; DoS; Communication Group of NDMA	2008–09	2010–12
3	Commissioning of APC facility	MoES/DoS	2008–09	2011–12
4	Implementation of multi-model cyclone prediction system	MoES with academic and R&D institutions	2008–09	2011–12
5	Establishment of lead-time cyclone impact assessment facility	MoES, MoWR, SRSAs SDMAs	2008–09	2010–12
6	Development of DSSs for emergency response planning and multi-lingual and multi-sector cyclone damage assessment	NCDMI, SDMAs, DoS, Sol-National Spatial Data Infrastructure (NSDI)	2008–09	2010–12
7	Cyclone Risk Management Actions by coastal States and UTs	SDMAs, SRSAs		2010–12

# 3

## Warning: Communication and Dissemination

### 3.1 Overview

3.1.1 An effective communication infrastructure is a pre-requisite for the proper functioning of cyclone warning and DM systems. The existing communication infrastructure backbone has been evolved over a period of time, using various communication technologies available from time to time. Several agencies play a vital role in providing the requisite inputs and information by using various communication networks.

3.1.2 Different types of networks are being used for cyclone warning and DM work, such as the Department of Telecommunications (DoT) telecom network for voice/fax, cellular telephone network, Disaster Warning System (DWS) terminals, NIC infrastructure and services, Internet Data Centre, Internet web-based network, radio broadcasting transmitters of AIR, International Maritime Satellite (INMARSAT) terminals, HAM radios, VSAT networks, etc. Some of these systems are vulnerable to cyclonic weather. In this chapter, the communication systems used by different stakeholders in DM are broadly discussed and improvement in the system suggested after gap analysis of the existing systems.

3.1.3 One of the critical short-term cyclone disaster mitigation measures is timely warning to the affected population and concerned officials connected with DM. The IMD issues user-specific warnings to various users like government agencies, ports, fishermen, merchant navy, media, farmers, general public, etc. Various modes of communication like telephone, fax, telex, radio broadcast, telecast, print media, Internet, railways

microwave network, etc. are used to communicate cyclone warnings to specific users as well as the general public. Cyclone Warning Dissemination Systems (CWDS) were introduced in India in the 1980s, and it is a fail-safe and rapid communication system to issue cyclone warning directly to the concerned communities from the IMD source using the INSAT satellite transponder.

3.1.4 The Ministry of Home Affairs (MHA) is the focal point at the national level and it coordinates appropriate dissemination of warnings received from IMD, CWC, etc. The district administration is the focal point for implementation of all governmental plans and activities. The actual day-to-day function of administering relief is the responsibility of the Collector/District Magistrate/Deputy Commissioner who exercises coordinating and supervising powers over all departments at the district level. Fail-safe communication infrastructure is essential to continue their functions in case of cyclone disasters.

3.1.5 Due to advancement in Information Technology (IT) in the form of the Internet, GIS, Remote Sensing, Satellite Communication, etc., it has become possible to plan and implement disaster reduction plans which, in turn, help to contain the damage on a long-term basis.

3.1.6 The weather channel is one of the leading modes of dissemination of weather information. Weather warnings can be communicated through a variety of formats (text, graphics, voice) and disseminated via a wide range of media (press, radio, television, e-mail, cell phone, Internet, etc.). Media broadcasts from the weather office are a



routine practice in advanced countries. However, an exclusive weather channel is not yet available in India. Radio broadcast of warning bulletins has proved to be one of the most effective and cheapest modes of cyclone warnings to communities the world over.

## 3.2 Present Status

### 3.2.1 India Meteorological Department

3.2.1.1 IMD is the nodal agency for providing cyclone warning services. IMD's INSAT satellite based CWDS is one of the fail-proof systems (satellite-based) currently in use in India to communicate cyclone warnings from IMD to communities and important officials in affected areas directly and quickly. The cyclone warnings are uplinked to the INSAT satellite in C-band. The satellite audio broadcasts in regional languages are continuously sent at fixed time intervals to the coastal CWDS receiving stations. These warnings are selective and received only by the likely affected receiving stations in S-band. IMD has installed specially designed receivers in the vulnerable coastal areas for direct transmission of warnings to officials and people in general.

### 3.2.2 CWDS Network in India

3.2.2.1 Area Cyclone Warning Centres (ACWC) of IMD generate these special warning bulletins and

transmit them every hour in the local languages. IMD has installed 252 such analog receivers in the field areas. The state-wise breakup of CWDS stations is given in Table 3.1

3.2.2.2 IMD is planning to replace the existing 252 analog CWDS by Digital CWDS (DCWDS) receivers and also to increase the number of DCWDS stations all along the east and west coasts of India. Besides this, 101 DCWDS stations are currently operational only along the coast of Andhra Pradesh, and one in Lakshadweep. Thus, the total number of CWDS and DCWD receivers currently in position is 353 with uplink stations at RMC-Chennai and IMD's Satellite Meteorological Division at New Delhi.

3.2.2.3 There are inherent technological and qualitative advantages of DCWDS as compared to the analog type CWDS.

All analog CWDSs will be converted into DCWDSs and some will be located at knowledge centres/ panchayat offices and community radio stations. The DCWDS network will be extended to adequately cover the cyclone prone coastal areas of the country.

## 3.3 Initiatives at the National Level

### 3.3.1 Ministry of Home Affairs (2003–05)

3.3.1.1 In recent years, the focus of DM is increasingly moving towards more effective

**Table 3.1 List of CWDS Stations installed in India**

Sl. No.	CWDS Stations (State-wise)	No. of Stations	Sl. No.	CWDS Stations (State-wise)	No. of Stations
1	West Bengal	31	7	Goa	1
2	Orissa	35	8	Maharashtra	8
3	Andhra Pradesh	81	9	Gujarat	19
4	Tamil Nadu	60	10	Daman and Diu	3
5	Kerala	5	11	Puducherry	3
6	Karnataka (including one at Hassan)	6		<b>Total</b>	<b>252</b>

utilisation of emerging technologies such as remote sensing, GIS and satellite communication, thus helping to prepare for and mitigate potential impacts. Under the existing framework in the country, the responsibility of undertaking rescue, relief and rehabilitation measures rests with the concerned state government. The central government provides financial and logistic support in the event of major disasters. A Crisis Management Committee (CMC) in the state, with senior representatives from government departments and central agencies located in the state, supervises DM actions and activities.

3.3.1.2 The collaborative programme on Disaster Risk Management taken up with UNDP support covers 169 multi-hazard-prone districts which include some of the cyclone-prone districts (out of 84) in the country and envisages assisting the states to draw up plans for district/block/village levels to build up effective resilience to disasters. Grass-root level participation in DM actions is also envisaged.

3.3.1.3 A National Communication Plan has been drawn up to harness the modern system of communication for information flow, dissemination of warnings, etc. A web-based inventory of specialist resources (India Disaster Resource Network, IDRN) required for DM support has been operationalised.

### 3.3.2 Ministry of Defence

3.3.2.1 Defence forces play a very important role during cyclone disasters. The Armed Forces are quickest to reach the affected areas for delivering timely action. Restoration of communication by them is very often a major contribution. The Air Force assists in search and rescue, evacuation and air-dropping of relief supplies. The Indian Navy and Coast Guard divers assist in rescue operations as well.

### 3.3.3 Operation Centre

3.3.3.1 In its basic form, an operation centre (OC) is functional with MHA. The communication network between the national and state Emergency Operation Centres (EOCs) and the site of the emergencies is currently based on the DoT network. This is the first casualty due to damage to communication towers and hence multi-mode communication systems are essential with enough redundancy for disaster time communication. POLNET is extensively used for DM requirements. For emergency communication, efforts are on with the Department of Space (ISRO) for making available alternate satellite communication units to connect state EOCs with mobile units which can be transported to the site of a disaster through SPACENET. Currently, about 35 SPACENET nodes are being made operational between NDMA/MHA with different state EOCs. The National Disaster Management Communication Group at NDMA is planning to set up satellite-based mobile voice/data/video communication between national EOC, state and district EOCs.

## 3.4 Gaps Identified

3.4.1 The terminal-end equipment and communication back-up equipment support is a bare minimum. The communication connectivity is purely Public Switched Telephone Network (PSTN)/Public Switched Data Network (PSDN) dependent. The OC at MHA would require due upgradation. For effective DM, both for routine activities and also during disasters, there is an urgent need to create a fully automated and state-of-the-art OC at NDMA and MHA with all terminal-end facilities and communication connectivity in various modes (voice, data and video) to respective SDMAs and SEOCs, DDMA and DEOCs, with the disaster sites. When NDRF arrives at the site, it helps to enhance last mile connectivity.



### 3.4.2 State/District Level Emergency Operation Centres

3.4.2.1 The primary function of a state EOC is to implement various DM activities under the supervision of the Secretary/DM Commissioner. At the district level, the Collector/District Magistrate/Deputy Commissioner is responsible for implementing all governmental DM plans and activities. Till the time the DEOCs become fully functional, the existing district control rooms will serve as nodal facilities for directing operations in emergency situations.

### 3.4.3 VSAT Network of the National Informatics Centre (NICNET)

3.4.3.1 The mode of NICNET communication is leased lines, VSATs, RF and ISDN/PSDN dial-up lines. The service provided over the network is primarily data. Voice and video is also provided in a limited scale. Video conferencing facilities are available in more than 450 locations.

3.4.3.2 NICNET has been offering network services over Ku-Band VSATs Single Channel Per Carrier (SCPC) - Demand Assigned Multiple Access (DAMA) and Frequency Time Division Multiple Access (FTDMA) - satellite broadband Digital Video Broadcasts (DVB), Wireless Metropolitan Area Networks (MANs) and Local Area Networks (LANs) with NICNET gateway for Internet resources. A high-speed NICNET national info-highway, an incremental overlay over the existing network has been set up with SCPC, FTDMA, TDMA VSATs, DVB Broadband

VSAT technology and wireless Metropolitan Area Network (MAN) to take advantage of the Internet technology in India. Various satellite networks in use by NICNET and their corresponding network technologies are shown in Table 3.2.

### 3.4.4 Satellite-based real time voice data messaging for Cyclone Warning System

#### 3.4.4.1 Common Alert System

Emergency managers need to send timely and appropriate alerts to everyone who needs them. Authoritative alert messages will be transmitted through all available communication media as appropriate, whether land-based, space-based or wireless, including individual targeting. Alerts can be converted automatically and securely from a standard format into forms suitable for each technology: the Internet, news media, television, radio, wired telephones, mobile phones, etc.

### 3.4.5 Satellite-based multi-lingual disaster warning software for DCWDS

3.4.5.1 Network Management Software (NMS) for Digital Cyclone Warning Dissemination Systems (DCWDS) is responsible for creation, transmission and monitoring of cyclone warning messages to unmanned satellite receivers installed all along the Indian coastal line. Audio messages, captured by a microphone, are digitised using MPEG-II format to create message packets in a customised protocol, with unique headers for selected stations. Header and message packets jointly form a data packet so that the required receivers are only energised by the transmission while others are not energised. Acknowledgement messages sent by the remote station's receivers are captured, analysed and checked periodically. All the transmitted messages and acknowledgement messages are logged systematically. IMD and concerned state governments are the users of this system.

**Table 3.2 VSAT services by NICNET**

Satellite Networks	Technology
DAMA	SCPC /DAMA
Direct Way	DVB/FTDMA
SkyBlaster	DVB/FTDMA

### 3.4.6 Digital Video Broadcast with Return Carrier through satellite (DVB-RC)

3.4.6.1 The DVB-RCS system supports communication in the channel in two directions:

- Forward channel from the hub-station to multiple terminals.
- Return channel from the terminals to the hub-station.

3.4.6.2 The forward channel provides 'point to multipoint' service because it is sent by a station at a single point to stations at many different points. The terminals share the return channel capacity of one or more satellite transponders by transmitting in burst, using multi-frequency-Time Division Multiple Access. This is a two-way communication system and suitable for DM.

### 3.4.7 EDUSAT

3.4.7.1 EDUSAT is the first Indian satellite designed and developed exclusively for serving the educational sector. It is mainly intended to meet the demand for an interactive satellite-based distance education system for the country. It strongly reflects India's commitment to the use of space technology for national development, especially in remote and rural locations. It is a collaborative project of the Ministry of Human Resource Development (MHRD), DoS and ISRO.

3.4.7.2 EDUSAT is being implemented through the following institutions:

- i) Indira Gandhi National Open University (IGNOU) Nodal Institution.
- ii) National Council of Educational Research and Training (NCERT).
- iii) University Grants Commission (UGC).
- iv) Indian Council of Agricultural Research (ICAR).
- v) All India Council for Technical Education (AICTE).

3.4.7.3 MHRD has been actively promoting the open and distance learning systems in the country. The launch of the Gyan Darshan bouquet of satellite-based TV channels and Gyan Vani FM Radio Network are recent examples. MHRD has also proposed the use of Information and Communication Technology (ICT) capabilities of the EDUSAT satellite for Elementary Education, Literacy, Vocational Training and Teachers' Training. At a later phase, it will expand to include Agriculture, Health and Community Development Programmes, etc. The EDUSAT network offers various application capabilities like virtual classroom, video-on-demand, database access, data transfer, online education and radio networking.

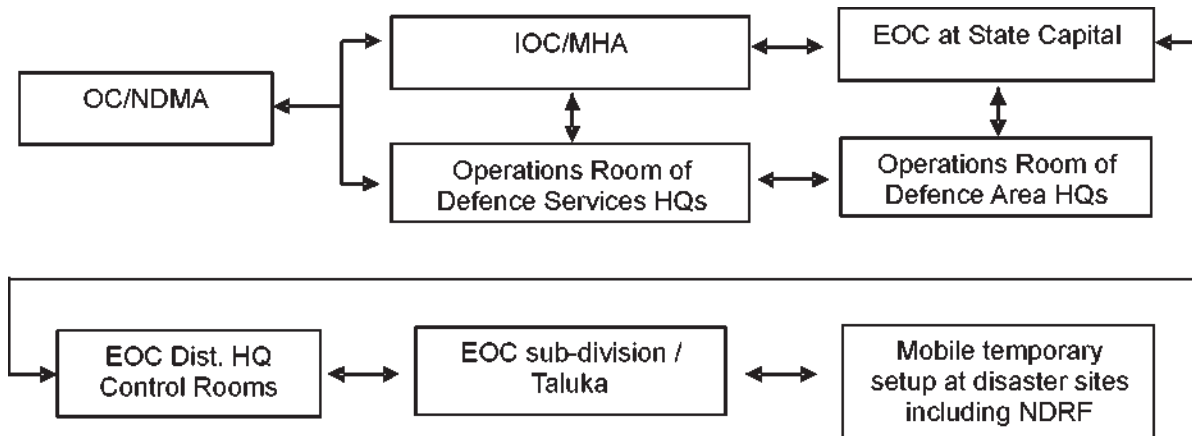
DM programmes will be developed and telecast on the EDUSAT network.

## 3.5 Communication Network

3.5.1 Feasibility surveys are being carried out in all states of India to establish a VSAT network linking the state headquarters with divisional and district headquarters, and a VHF radio network linking the district headquarters with sub-divisional and taluka headquarters which will have control at the national level.

3.5.2 Various technology options are available to provide communication among EOCs at the national and state capitals, district headquarters control rooms, sub-divisional/taluka level set-up and, finally, mobile, temporary VSAT set-ups at the disaster sites. A block diagram of the proposed communication hub network and technology options for communication and connectivity are given in Figure 2. In the rare event of a failure of the civil communication network, it will be connected with headquarters and operations room of the Defence Services command/area/sub-area and local level to augment the communications further as per the local requirements.

Figure 2 Block Diagram of Proposed Communication Hub



### 3.6 Communication Support for DM

3.6.1 For efficient management of disasters, an effective communication system is one of the key factors. DM involves organizations and departments, both governmental and non-government, including the affected community.

3.6.2 The basic communication and IT support for DM is therefore required for the following:

- i) Monitoring and forecasting agencies like IMD, CWC, NRSA and DoS and so on.
- ii) Governmental machinery for giving out early warning of impending disasters/disaster-like situations.
- iii) NDMA/OC will link with all stakeholders in a bilateral mode at the national, states/UTs and district levels, both for routine functioning as well as management of EOCs during disasters.
- iv) Communication and IT support is also required for various other ministries, departments and organizations involved in DM along with NDMA. This is mainly for coordination and execution. ICT linkages would be required for all such users.
- v) Response forces such as NDRF, SDRF, Para Military Force (PMF), Police, Defence forces,

Corporate, NGOs and any other organization, national or international.

### 3.7 Existing Backbone Communication Infrastructure

3.7.1 As already stated, the communication infrastructure is a pre-requisite for proper functioning of the cyclone warning and DM system. The existing communication infrastructure has evolved over a period of time using various communication technologies available from time to time.

#### 3.7.2 Direct-to-Home (DTH)

3.7.2.1 DTH service provides different language channels in every nook and corner of the country. The most significant aspect of DTH broadcast is its digital quality, fail-proof communication. Apart from the DTH service of Prasar Bharati (PB), private broadcasters like Dish TV and Tata Sky also provide services on different television channels all over the country.

Since the DTH services of PB, Dish TV and Tata Sky are providing reception in remote and rural areas, the services of DTH, Dish TV and Tata Sky will be utilised for dissemination of cyclone warnings and for weather information on radio/TV channels to the places not covered by terrestrial and cable operators.

### 3.7.3 World Space Satellite based Digital Broadcast Service

3.7.3.1 IMD has started a new meteorological data and processed products broadcasting service from 1 July 2003 using the World Space 'Asia Star' satellite. This is a replacement of the HF broadcast system which has become outdated.

3.7.3.2 The receiving system consists of a satellite receiver and a Digital Data Adaptor (DDA) designed exclusively to work with the World Space Satellite System and can be used to visualise data, satellite images, weather charts, automatic plotting of data, analysis and manipulation of data for the benefit of weather forecasters and other users. This could be considered as an alternative option. From such warning broadcasts, besides others, the fishermen out at sea will be benefited the most.

### 3.7.4 Community Radio

3.7.4.1 Community radio is defined as radio that is owned by the community and airs programmes designed and produced by it specifically for its own developmental needs. The communities that produce these radio programmes cablecast, narrowcast or buy time from the AIR local radio stations. In order to give wide publicity of natural disasters among the communities, community radio will be established in cyclone-prone areas with the help of IGNOU and other open universities, NGOs and Community Based Organisations (CBOs); the cost if any, will also be met by them. If a DCWDS receiver can be co-located with the community radio, it will add value and considerably increase the outreach of warnings.

### 3.7.5 Battery-less Hand Radio

3.7.5.1 It has been reported that corrosion of batteries in transistors carried by some fishermen out at sea is one of the major reasons for the non-receipt of warning broadcasts by AIR, besides attenuation of signals in adverse weather. Some

battery-less, low-cost hand radios are now available in the market which will be useful for receiving warnings by fishermen at sea where battery operated radios generally do not work.

Battery-less hand radio sets will be provided to fishermen.

### 3.7.6 Satellite Phone Services

3.7.6.1 At the time of emergencies, a communication system with clear voice and data communication facility having mobility and reliability, are important factors. Satellite phone services provide these assurances almost anywhere in the world, even in areas of total devastation and in areas where even electricity is not available. Satellite portable phones work like cellular phones where cellular coverage is available, and as satellite phones where it is absent. The communications are completely independent of any local telephony infrastructure. One need not worry about service disruptions because of power failures or other events common in disaster areas. Therefore, satellite phone services can be extremely useful in saving lives and coordinating efforts during rescue operations, such as the setting up of telemedicine links up to the taluka/mandal level. These phone services can be used by the Red Cross, doctors, police, fire departments, ambulance services, search and rescue, NDRF, district collectors and other government emergency response organisations.

### 3.7.7 Mobile Phone

3.7.7.1 Currently, there are two types of mobile phone technologies available in India. These are broadly known as Global System for Mobile communications (GSM) and Code Division Multiple Access (CDMA). BSNL and MTNL and some private telecom companies like Bharti, Reliance, Tata, Idea, Vodafone offer both GSM and CDMA mobile phone services in India. Some GSM operators offer GPRS services also, where a download speed of up to 30

kbps is available. The battery- based mobile base stations can be quite helpful during natural disasters when electricity supply links become inoperative. Besides voice communications, nowadays mobile phones also provide pay services like Short Message Service (SMS), news updates, railway and airline information, etc., that can be used by subscribers.

BSNL/MTNL and all private telecom companies will provide capability to access the designated four-digit toll free number for information related to cyclone alerts and warnings from landlines and mobile phones.

### 3.7.8 Cell Broadcast

3.7.8.1 A GSM mobile network can provide the facility to broadcast short messages to mobile phone users within the network of an operator on a real time basis (in seconds). This is the cell broadcast facility.

3.7.8.2 Radio and TV stations can have access to the cell broadcast facility via an entry provided by the GSM mobile network operator. Various areas can be identified using GIS. For every area, an emergency message can be specified such as for cyclone alert, cyclone warning, etc. This message can be broadcast on a regular basis (for example, every 5 minutes). As time passes, the broadcast message can be updated, or removed if necessary. It is also possible to specify messages in various languages so that end-users can receive emergency notifications in their native language. Geneva Technologies of Bangalore has developed an automated multi-lingual SMS generation software in 14 regional languages through a joint effort with the Department of Science and Technology and IMD.

#### Highlights

- i) Real time emergency notification via GSM mobile phones.

- ii) Location specific information repeated frequently and updated if required.
- iii) Areas can be identified with powerful GIS.
- iv) Communities can be informed in their languages.
- v) Cost-effective solutions for mass communication by making use of existing infrastructure.

#### Prerequisites

- i) Cell broadcast entry at emergency organisations to specify messages per area.
- ii) Standardised emergency channels provided by mobile network operator(s).
- iii) Create user awareness to activate appropriate cell broadcast channels on mobile phones (optionally, this can be done by the operator).

3.7.8.3 Cell broadcast is a non-intrusive push technology as mobile users are able to activate or de-activate a certain cell broadcast channel (similar to adjusting a radio or television to a certain channel).

### 3.7.9 Internet

3.7.9.1 In the present era of electronic communication, the Internet provides a useful platform for DM communications. Launching of a well-defined web site is a very cost-effective means of making an intra-national and international impact. It provides a new and potentially revolutionary option for the rapid, automatic and global dissemination of disaster information. A number of individuals, organisations and groups, including IMD, are using the Internet for real time dissemination of weather observations, forecasts, satellite and other data. In the most critical phase of natural disasters, electronic communication has provided the most effective, and in some instances perhaps the only means of communication with the outside world.

### 3.7.10 News-on-Phone

3.7.10.1 AIR has started an interactive broadcasting service 'AIR News-on-Phone'. AIR listeners now do not have to wait for the broadcast time to listen to the news. AIR news highlights can now be accessed on any type of telephone, at any time and from anywhere in the world. For this purpose, AIR news headlines are directly recorded and stored in a dedicated computer system connected with a telephone interface for subsequent retrieval on telephone lines. The recording as well as playback of the news is achieved in real time. Through this service, listeners can access a capsule of the latest news highlights in Hindi and English, on telephone. Such a system can be put into operation at the time of emergencies like natural disasters.

### 3.7.11 Emergency Warning System for Analog Broadcasting

3.7.11.1 This system uses relatively simple equipment and ensures stable operations. In an emergency, the emergency warning system control signal replaces the radio and TV programme signals and automatically activates the emergency warning system ready receivers even when they are in sleep mode.

3.7.11.2 In digital broadcasting, the emergency warning system control signal is transmitted by multiplexing with the broadcast wave to automatically activate the receivers even when these are in sleep mode. The emergency warning system signal will be robust to prevent its misuse.

It is anticipated that in future the digital emergency warning system function will most likely be incorporated in mobile hand-held devices. Sending emergency information to these terminals will be highly effective as these will be carried by the general public when the mobile TV becomes popular.

### 3.7.12 Radio Receivers for Emergency Warning System

3.7.12.1 AIR has a large network of AM/FM transmitters which can be effectively used to convey emergency messages to the public on natural disasters. Since all these transmitters are of analog type, it will be advisable to go in for the digital receivers.

3.7.12.2 A transmission format which has fixed code will be more suitable for India as it does not contain the area code. The CD containing EWS control signals can be played back on AM/FM transmitters located in the region affected by natural disasters as an alarm for users of analog radio receivers even in sleep mode. A simple algorithm that runs on a tiny microprocessor needs to be installed in the receiving device. The device can be pre-installed in radio sets by electronics manufacturers. This can also be considered as an alternative option.

### 3.7.13 Digital Radio Mondiale (DRM) Transmitter

3.7.13.1 This technology developed by a consortium of broadcasters and equipment manufactures, uses the broadcast band below 30 MHz. It gives near FM quality with the existing bandwidth available in MW/SW band. This system also has the option of data broadcasting and added features like programme associated data (PAD) or additional speech channel. This system uses the existing band of frequency allocated for MW and SW broadcast. Due to its long-range coverage in the SW band, the broadcaster can reach across the continent carrying digital programmes without any fading. The technology is fully developed and more than 60 broadcasters all over the world are using digital transmission.



3.7.13.2 The following are the advantages of this technology:

- i) A large area can be covered from own home territory by using a single-station infrastructure.
- ii) Common disadvantages like night-time shrinkage, interference due to manmade noise of the AM bands will disappear.
- iii) It is capable of supporting additional channels for associated data and programme aided data.
- iv) It is possible to have an additional speech quality and data channel within the available RF bandwidth.
- v) It has a cost-effective receiver system which is compatible with all modes of radio transmission (analog as well as digital).

3.7.13.3 A proposal for replacement of the existing 50 kw SW transmitters at Port Blair, Hyderabad, Thiruvananthapuram, Mumbai and Chennai by DRM is under consideration.

DRM Transmitters will be installed to cover all cyclone prone states/UTs.

### 3.7.14 Common Services Centre Scheme

3.7.14.1 The Government of India has formulated the National e-Governance Plan (NeGP) with the vision of providing all government services in an integrated manner at the doorstep of the citizen, at an affordable cost. NeGP initiatives consist of 26 central, state and integrated Mission Mode Projects (MMPs) along with eight other support components for rapid introduction of e-governance in the country. NeGP envisions a three-pillar model for delivery of 'Web-enabled Anytime, Anywhere, Anyhow access' to information and services in rural India.

These are:

- i) Connectivity: State Wide Area Networks (SWANs)/NICNET.

- ii) National Data Bank/State Data Centres (SDCs).

- iii) Common Services Centres (CSCs).

3.7.14.2 The CSC scheme has a 3-tier implementation framework:

- i) At the first (CSC) level, it would be the local village-level entrepreneur (VL-loosely analogous to a franchisee) to service the rural consumer in a cluster of 5–6 villages.
- ii) At the second/middle level, it would be an entity termed the Service Centre Agency (SCA—loosely analogous to a franchiser) to operate, manage and build the VLE network and business. An SCA would be identified for one or more districts (one district would cover 100–200 CSCs).
- iii) At the third level, it would be the agency designated by the state—the State Designated Agency (SDA), to facilitate implementation of the development scheme within the state and to provide the requisite policy, content and other support to SCAs.

3.7.14.3 Determining the CSC location

- i) The aim of the CSC scheme is to establish 100,000 rural kiosks across the country with an equitable spread at the rate of one CSC for every six census villages. The state government will have to work out the number of CSCs that will be established in each block across the state, based on the above parameter.
- ii) The SCA may be given the discretion to locate CSCs anywhere within a block within the overall ceiling arrived at, based on the criterion mentioned above. The SCA, however, would need to ensure that not more than one CSC is established in one gram panchayat, unless the number of gram panchayats in a block is less than the

number worked out, based on the criteria mentioned above.

DIT/states/UTs will set up one CSC for every census village in cyclone vulnerable coastal states and UTs.

- iii) Wherever the state government proposes to set up a larger number of CSCs than those prescribed as per the criteria mentioned above for certain specific reasons, prior approval of the Department of Information Technology (DIT), Government of India, would need to be taken by the concerned state government.

### 3.7.15 State Wide Area Networks (SWAN)

3.7.15.1 In the states, SWAN is the approved scheme of Gol for interconnecting state headquarters with District headquarters and District headquarters with Block headquarters with minimum 2 mbps leased lines, in order to create a secure government network for the purpose of delivering Government-to-Government (G2G) and G2C services. The scheme is approved for 29 states and six UTs at an estimated outlay of Rs 3,334 crore, with Rs 2,005 crore as grant-in-aid from DIT. The balance fund would be supported by the state plan. The pre-project implementation period is 18 months with a five-year operational period. This scheme is presently at various stages of implementation across the country. The National Informatics Centre (NIC) currently operates a Ku-Band VSAT network connecting all districts (barring a few newly created ones) with 64 kbps satellite link. Some districts in the country are also connected to the video-conferencing facility on NICNET through 2 mbps DAMA VSATs. Orissa is implementing a VSAT network up to the block level through NIC. NIC is currently planning restructuring and augmentation of the existing NICNET as a viable G2G network in order to position it as the core infrastructure for G2G data and video interactions.

3.7.15.2 Implementation options for the states include:

- i) Using NIC to establish SWAN by suitably extending the existing NICNET up to the block level.
- ii) To engage a competent private/public sector agency through an appropriate competitive bid process and under a suitable service level agreement [Build Operate Own (BOO)/ Build Operate Own Transfer (BOOT etc.)], to establish and run the SWAN.
- iii) To establish and own the SWAN infrastructure directly by the state and use a private service provider for operations and facility management.
- iv) Any other Public Private Partnership (PPP) model considered appropriate by the state.

3.7.15.3 State/UT governments are presently adopting one of the two options approved in the Scheme: Option-I is Public Private Partnership (PPP) and the other is the NIC option. In the PPP option, the state/UT government would be implementing the SWAN project by selecting the network operator at the state/UT level by following a competitive bid process. In Option-II, NIC will be the implementing agency and NIC would be operating the SWAN on behalf of the state/UT concerned for the next five years.

3.7.15.4 All these SWANs would be connected through NICNET for all central applications, for which suitable guidelines for standardization, interoperability and interconnect requirements between NICNET and the SWANs and also between different SWANs have been worked out. The network architecture for such SWANs has been specified. SWANs set up under Option-II would necessarily have the required interconnectivity with NICNET. Irrespective of the implementation option adopted, existing NICNET infrastructure would be used as a back-up for emergencies and disasters.



Seamless interface between NICNET and SWANs will be established by state governments for implementation of voice/video/text communication facilities up to the block level on priority.

### 3.7.16 Village Information Centres (VICs) of the Department of Science and Technology (DST)

3.7.16.1 The setting up of VICs is supported by DST as part of its major initiative to provide information and empower the rural population with the fruits of Information and Communication Technology (ICT). DST provides all the infrastructure support for operating an information kiosk in any village under the supervision of the state government, technical institutions such as state S&T councils, technical universities, remote sensing application centres, IT departments, etc. In a pilot mode, all digital topographic and thematic maps are being generated to assess the village level vulnerability in about 20 villages in Andhra Pradesh – 10 cyclone vulnerable villages in Nellore District and 10 drought vulnerable villages in Kadapa District. In Prakasam District of Andhra Pradesh, 40 VICs will be set up in association with Jawaharlal Nehru Technological University. All the VICs will have an automatic weather station to collect local weather information for disaster-time scenario assessments. Details of the establishment plans of VICs in other states include:

- i) Karnataka: All 28 districts with spatial data information, scaled up to seven village level
- ii) Tamil Nadu: Seven districts
- iii) Kerala: Four districts

Such VICs will be utilised in addition to CWDS for communicating cyclone warnings and emergency messages directly to the community.

### 3.7.17 Weather Channel and Weather Portal

3.7.17.1 The weather channel can be one of the leading sources of weather information. Weather

warnings can be communicated using a variety of formats (text, graphics and voice) and disseminated through as wide a range of media (press, radio, television, e-mail, mobile phone, the Internet, etc.) as possible. Media broadcasts from the weather office and or radio and television interviews with one or more authoritative figures can be effective in triggering responses from people.

3.7.17.2 The weather network of Canada has an e-mail service called Weather Direct, which sends weather forecasts via e-mail. There is also a text message service which sends forecasts on wireless phones.

Weather portals will be developed and deployed by IMD with full interface with cellular service providers and broadcasters to deliver weather warning services on radio, T.V. and mobile phones.

## 3.8 Development of State-of-the-Art Dissemination and Communication Infrastructure

### 3.8.1 Essential Requirements of State-of-the-Art Infrastructure

3.8.1.1 The entire disaster mitigation game-plan must necessarily be anchored to frontline research and development in a holistic mode. State-of-the-art technologies available worldwide will be made available in India for upgradation of the existing DM system. At the same time, dedicated research activities will be encouraged in all frontier areas related to disasters, for a continuous flow of high quality basic information for sound DM planning.

### 3.8.2 Options for Last Mile Connectivity

3.8.2.1 Coastal states and UTs can explore and adopt appropriate options offered by Gol and corporates according to local suitability to establish the desired last mile connectivity for cyclone warning communication and dissemination. Village

Knowledge Centres (VKCs) are a joint effort of the M.S. Swaminathan Research Foundation (MSSRF), DoS and NABARD.

3.8.2.2 MSSRF scientists have tried a variety of communication technologies for transferring (and disseminating) information (voice, data, image, etc.) between the knowledge centres. These include the Internet, VHF two-way radio, spread spectrum, World Space Radio, satellite communication using C- and Ku-Bands and low-cost wireless (208.11) technology. Currently, VKCs are operational in about 50 locations in Tamil Nadu. The cost of taking connectivity to the villages is an area that the DIT has been focusing on, including the price of devices and networking equipment. Generating a synergy between different technologies, particularly between the Internet and the community radio and synergy among all the institutions engaged in the field of technological and skill empowerment of the vulnerable population in seamlessly disseminating customised disaster warnings is necessary.

3.8.2.3 Transaction costs will have to be kept low and a sense of ownership can be created by fostering the growth of ICT through the self-help groups (SHG) movement. An appropriate mix of numerous ICT tools – the Internet, cable TV, radio, cell phone, and the English Language and vernacular press will be used for information dissemination. The government is focusing its attention on rural India. The Telecom Regulatory Authority of India (TRAI) is now building strategies for accelerating the growth of telecom infrastructure and for bringing down the costs of communication. Many national institutions—IGNOU, NIC and State Open Universities—are keen to reach out to the rural masses. State governments are deeply interested in harnessing ICT for sustainable development. ISRO is launching a satellite specifically dedicated to education as well as the Village Resource Centre Programme initiatives by the Gol and corporate sectors.

### 3.8.3 Cuddalore (Tamil Nadu) Model

3.8.3.1 It has been observed that fishermen out at sea, salt pan workers, unorganised migratory labourers working along the coast, ship breaking communities and weaker sections of the coastal communities are generally caught unaware of the danger from the cyclones due to non-receipt of timely warnings. As a result, they suffer the most in the event of a cyclone disaster. Therefore, to reap the benefits of improved early warning systems, the timely communication of cyclone warnings to coastal communities as a whole, and especially to the above-mentioned groups of coastal communities is extremely important. It is well known that even with the best of early warning systems, the results will still be catastrophic if the early warnings are not properly interpreted and communities are not educated and trained to respond to the early warning in real time. Therefore, the establishment of a communication network for the timely dissemination of cyclone warnings to coastal communities (being the first responder) by improving last mile connectivity and also educating coastal communities to interpret and respond to the warnings properly is essential. Among several options, the establishment of VHF (Very High Frequency) wireless network, integrated with a Public Address System (PAS) for efficient and quick dissemination of cyclone early warnings in remote coastal areas is a good option and is being recommended to be followed. The system is a low cost option which is simple to use and maintain. All the coastal states have experience of using such systems (VHF sets).

3.8.3.2 These communication facilities will be made available in every coastal village. The communication equipment will be placed in a pre-identified sturdy room of a village which will virtually serve as a Village Emergency Operation Centre in the case of any emergency, including cyclone. In fact, the Government of Tamil Nadu, which is

currently establishing a VHF-based network for last mile connectivity for early warning communication in Cuddalore district with UNDP assistance, is a good model. Other communication options for last mile connectivity need also to be explored.

### 3.8.4 Organisation and Management of Village Knowledge Centres

3.8.4.1 ICT-SHGs may be promoted to organise and manage these knowledge centres. NABARD may provide loans to the tune of Rs 1 lakh per knowledge centre. This includes the cost of computers, uninterrupted power supply (UPS), modem, CD writer, web camera, printer, scanner, copier, fax, furniture, electricity, Internet, etc. Satellite transmission would enable disaster-related content to be easily pushed on to the server, data additions would be made simpler and services from the government could be generated and relayed to its end-users. VKCs or VRCs are the right kind of initiatives in which ISRO can piggyback and, in the process, bring the benefits of space directly to the grass-root level.

### 3.8.5 Corporate Initiatives

3.8.5.1 A few information kiosks were set up by large industrial houses, essentially to reach out to clients and supply them with products useful to them (ITC's e-chaupal and Hindustan Lever's iShakthi). n-Logue, an IT company largely promoting the technologies developed by IIT Chennai, has a franchise model wherein they provide an info kiosk (PC with internet and video-conferencing facility, scanner, photocopier, etc.) at low cost and trains the kiosk owner. The owner provides different services and tries to earn a reasonable income from the services he provides.

## 3.9 Integration of Networks

3.9.1 The integration of networks set up by various agencies will be an important aspect of

establishing various types of networks in the country for DM. The networks and resources under considerations are:

- i) Those set up by central government agencies (POLNET, NICNET, SPACENET RAILNET etc.)
- ii) Those set up by the state governments, such as SWAN, or under e-governance projects. These would include:
  - a) Village resource centres
  - b) Village information centres
  - c) Village knowledge centres
  - d) Community service centres

3.9.2 To extend the outreach of warnings, it is essential to integrate the warning systems with PAS to ensure simultaneous dissemination of warning messages to the public at large. A single platform for all networks such as Transmission Control Protocol/Internet Protocol (TCP/IP), to reduce problems of interfacing between different networks, can also be explored.

## 3.10 Priorities at State/District Level

### 3.10.1 Short-Term Plan

- i. Preparation of a directory of staff dealing with DM, including telephone numbers (landline and mobile) and e-mail addresses for internal as well as external use.
- ii. Installation of CUG based intercom – One Touch Dialing.
- iii. Manual communication and IT gateways for connection to various other agencies and service providers.
- iv. Establishment of mini/startup EOCs.
- v. Creation of mobile communication access platforms and mobile EOCs.

- vi. Setting up a multi-lingual (Hindi/English/ state specific language) state level DM website

### 3.10.2 Mid-Term Plan

- i) Setting up a call centre based multi-lingual helpline
- ii) Establishing a Virtual Private Network (VPN) based DM information service network
- iii) Upgradation of manual communication and IT gateways to automatic ones, including the capability to provide hotlines/video conferencing on demand
- iv) Establishment of full-fledged data centres
- v) Upgradation of the communication set-up of EOCs
- vi) Refinement of communication and IT plans and Standard Operating Procedures (SOPs)
- vii) Automation of DM information flow

### 3.10.3 Long-Term Plan

- i) Creation of seamless gateways
- ii) Establishment of dedicated and high speed communication and IT networks
- iii) Automated and software-based integration of early warning inputs and the associated dissemination to areas and communities likely to be affected, in a multi-mode, redundant and self ensuring environment
- iv) Updation of SOPs in tune with established and emerging communication and IT networks

### 3.10.4 District Level EOC

- i) There is a genuine need for caller digital antenna at emergency operation centres.
- ii) Digital signboards need to be displayed on roads approaching a cyclone-prone area so

that the local people have full information about cyclones.

- iii) High Flood Level (HFL) and storm surge level markings need to be indicated in villages.
- iv) A warning siren, with a different type of warning tune, needs to be commissioned in cyclone prone areas.
- v) There is a need for light indicators around the fishing vessels area.

## 3.11 Implementation Issues

3.11.1 The various communication options discussed earlier in this chapter have their own advantages and disadvantages. There are some pre-requisites for the smooth running and successful operation of each component. The choice of the type of communication will therefore be area specific and need based. However, whatever may be the choice of the communication set-up, it needs to be kept in mind that these are integrated or made compatible with other existing or planned national systems.

## 3.12 Major Action Points

1. Integration of the existing satellite-based communication networks, namely NICNET, POLNET, EDUSAT, RAILNET and SPACENET, will be taken up on priority for utilising the available bandwidth for various emergency response actions and warning dissemination as explained below:
  - i) SPACENET for disseminating customised warnings and maps from DSSs among operational agencies (refer section 3.3.3).
  - ii) NICNET for disseminating EW and hazard maps for relief and rehabilitation actions. Seamless interfaces between NICNET and SWANs will be

established, on priority, for implementation of voice/video/text communication facilities up to the block level (refer sections 3.4.3, 3.7.14.1, 3.7.15, 3.9.1).

- iii) EDUSAT for focused disaster management education, awareness and sensitisation programmes (refer section 3.4.7).
- iv) POLNET for coordinating activities among the security forces, e.g., Army, NDRF, Paramilitary Forces (refer section 3.9.1).

[Action: Ministry of Communications, Ministry of Information Technology (MoIT), Ministry of Home Affairs (MHA), Ministry of Human Resource Development (MHRD), Department of Space (DoS), Ministry of Railways, State Government Departments/Agencies]

- 2. Seamless connectivity up to the last mile by interfacing NDMA, SDMAs, DDMAs with panchayats will be established on a fail-safe NDCl, with redundancy by interfacing with EDUSAT network (refer sections 3.4.1, 3.4.2, 3.4.3 and 3.8.2).

[Action: NDMA Communication Group]

- 3. DCWDS and community radio stations will be co-located, as far as possible, so that the warning dissemination outreach can be appreciably enhanced (refer section 3.4.5).

[Action: Prasar Bharati, Ministry of Earth Sciences-India Meteorological Department (MoES-IMD)]

- 4. It will be mandatory for all TV channels and local cable networks to flash/stream/scroll cyclone alerts and warnings based on news

bulletins issued by appropriate authorities (refer section 3.7.2).

[Action: Ministry of Information and Broadcasting, Ministry of Information and Technology, State/UT Departments of Information]

- 5. Multi-lingual and multi-sector warning dissemination supports involving all the available services from DTH, satellite radio, community radio, hand radio (battery free), satellite phones, mobile phones, SMS/MMS broadcasts, Web GIS, SW radio, data transfer through FM stations, etc. will be developed (refer sections 3.7.2.to 3.7.8).

[Action: Prasar Bharati, private broadcasters, cellular operators, World Space; Internet service providers regulated through TRAI]

- 6. Establishment of state wide-area networks (SWAN) will be expedited up to the block and panchayat levels and will be linked with NICNET for district, state and national level communication support of voice/video/text transmission. Redundant communication options will be developed at the village level through DCWDS/CSC/VKCs/VIS options (refer sections 3.7.15, 3.9).

[Action: NICNET, state governments/UTs, Department of Science (DoS), Department of Science and Technology (DST), Ministry of Earth Sciences-India Meteorological Department (MoES-IMD)]

- 7. Efforts for commissioning Web GIS-based weather portal and a weather channel will be expedited with interfaces with weather agencies, cellular services providers and terrestrial broadcasters to deliver weather-based disaster services (refer section 3.7.17).

[Action: Ministry of Earth Sciences (MoES)]

### 3.13 Implementation Strategy and Time-Frame

responsibility of implementing the guidelines in this chapter.

#### 3.13.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the

3.13.2 Following is the time-frame for implementation of activities listed in this chapter:

#### Time-Frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commencement	Action and Date of Completion
1	Establishment of integrated satellite based disaster communication infrastructure [SPACENET-NICNET-POLNET]	Communication Group of NDMA, SDMAs, MHA	2008–09	2010–12
2	Establishment of seamless connectivity of NDMA, SDMAs, DDMA's with SWANs, etc. with blocks/panchayats	Communication Group of NDMA, SDMAs, MHA	2008–09	2010–12
3	Commissioning of 2-way data transmission	Prasar Bharati; Private Broadcasters; Service Providers	2008–09	2011–12
4	Establishment of multiple disaster warning broadcast platforms for fail-proof community-level dissemination	DST, MoES, Ministry of Information Technology (MoIT), TRAI	2009–10	2011–12
5	Establishment of lead time cyclone warnings through Weather Portal and Weather Channel	MoES, Prasar Bharati	2008–09	2011–12
6	Commissioning of DCWDS co-located with coastal Community Radio Stations	MoES	2009–10	2011–12



# 4

## Structural Mitigation Measures

### 4.1 Overview

4.1.1 Severe cyclones not only wreak colossal damage to non-engineered buildings such as thatched roofs, tiled houses, etc., but also cause heavy damage to semi-engineered buildings such as schools, workshops and factory buildings, etc., and well-engineered structures including communications, transmission and windmill towers. Some of the typical failures of buildings and structures during cyclones were observed during post-cyclone damage surveys conducted by the Structural Engineering Research Centre (SERC), Chennai, and IMD on several occasions.

4.1.2 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 utilised 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.

4.1.3 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.

4.1.4 It is very important to provide safe shelters to protect human life at the time of cyclones. Many cyclone shelters constructed earlier were not connected by all-weather roads with nearby habitats from where affected people need to be shifted during emergency evacuation.

4.1.5 There is a need to improve the existing road network and provide at least one link road, in all-weather conditions, for each village that is accessible during cyclone or flooding periods as well. The importance of coastal canals need not be over-emphasised as it serves as an alternative to road communication in the event of a cyclone or flood. Failure of even well-engineered structures such as communication and transmission towers during past cyclones brings the importance of the structural safety of such structures to the forefront.

4.1.6 There are several Indian Codes and Standards, such as IS:875-1987 (part.-3), IS:456-2000, IS800-1984, the National Building Code, among others, which detail out the requirement for the design and construction of structures, taking into account wind loads as well. Likewise, there are Indian Road Congress (IRC) specifications which cover roads/culverts/bridges.

4.1.7 Concerted R&D activities in the field of cyclone disaster mitigation have been carried out in several premier institutions in India, and in

particular, at the SERC, Chennai and Indian Institute of Technology, Roorkee (IIT Roorkee). Simple design and construction guidelines to improve the cyclonic resistance of various buildings and structures have been brought out and they are incorporated in the Indian Standard Code of Practice, viz., IS: 15498-2004, "Design and Construction of Buildings and Structures in Cyclone Prone Regions". A document was drafted to detail out the "Guidelines for Mitigative Measures Related to Cyclones" at IIT Roorkee for the Gujarat State Disaster Management Authority (GSDMA) as part of a World Bank-sponsored project.

4.1.8 In a nutshell, it may be said that know-how is available in India for speeding up cyclone disaster mitigation activities. The basic mechanism is also available, by and large, to take up these activities. The need is to further strengthen and activate the machinery backed up with adequate resources.

## 4.2 Buildings: Cyclone Shelters

4.2.1.1 Loss of life due to cyclones is largely due to the lack of an adequate number of safe shelters which can withstand the fury of cyclones, including wind and storm surge.

4.2.1.2 Circular cyclone shelters were initially constructed but they deteriorated very soon due to lack of proper usage and maintenance. While most of them have been dismantled, others that remained are in a dilapidated condition, unfit for use.

4.2.1.3 Shelters constructed at a later stage were designed differently but were largely meant to be used only as cyclone shelters. It is only in recent years that the concept of multi-purpose cyclone shelters has come into vogue.

4.2.1.4 Apart from the cyclone shelters, many other buildings have been used to provide shelter to people evacuated from affected areas. These include schools, places of worship, community halls, etc. An inventory of all such available buildings is generally maintained by the district administration. However, with more multi-purpose cyclone shelters being constructed, the relief operations can get streamlined.

### 4.2.2 Assessment of Needs

4.2.2.1 An assessment of the total requirement of cyclone shelters has to be made by all the states/UTs. The factors that need to be considered are:

- i) Vulnerability of the area,
- ii) Percentage of the total number of people in a habitation/village that would have to be evacuated after taking into consideration the available and planned buildings like schools, places of worship, community halls, etc.,
- iii) Communication requirements, and
- iv) Identification of sites

Coastal villages/habitations prone to frequent cyclone impact that do not have any suitable safe shelters will identify and reserve a suitable place to construct cyclone shelters, even if the actual construction is taken up at a later stage.

### 4.2.3 Design Considerations of Structures

#### 4.2.3.1 General Considerations

Buildings, shelters and lifeline structures will be designed on the basis of existing codes and standards. The material and design specifications and their criteria will be such that minimum maintenance is needed and the structures can withstand adverse weather conditions.



**General Design Considerations for Buildings**

- i) The design to be carried out for 1.3 times the basic wind speed as recommended in the IS 875 - 1987 part 3. The basic wind speed as per the code in most parts of the coastal zone is 50 m/s (180 km/hour) up to 10 m above ground level. Further, a number of corrections are to be applied based on the importance of the structure (risk assessment), topography, size and shape of the building.
- ii) The design will also be able to withstand seismic forces in regions which are additionally vulnerable to earthquake hazard, such as Kandla, etc.
- iii) The local community will be encouraged to construct houses which will be cyclone resistant. Urban Local Bodies (ULBs) and Panchayati Raj Institutions (PRIs) will be asked to ensure this.
- iv) Sloping RCC roofs (say 1 in 5 or 6 slope) will be used to provide quick rain water drainage and avoid any seepage or leakage.
- v) Minimum M30 Concrete grade (concrete having a characteristic strength of 30 N/mm<sup>2</sup>) and reinforcement steel of Fe415 grade will be used in the construction. A design concrete mix as specified by IS Code 456 will be adopted.
- vi) An extra cover of 5 mm beyond that specified in IS: 456 for the relevant exposure condition is to be provided for steel reinforcement.
- vii) The materials used for construction, viz. reinforcement, aggregates and water, will be tested as per the codes provided before their use. The durability of the structure depends on the quality of the basic materials and quality assurance of the construction.
- viii) The walls and all the RCC work will be plastered with cement mortar of 1:4. The

outside plaster can be in two coats. The building will have suitable cement plaster coating both outside and inside.

- ix) The doors and windows will be of aluminium with anodized fixtures. The size and thickness of the doors and windows must be of heavy gauge quality.
- x) All inserts and fittings will be of structural aluminium.

**Special Design Issues for Multipurpose Cyclone Shelters (MPCS)**

- i) The cyclone shelter is primarily designed to shelter people and sometimes even cattle, during cyclones. However, it will be utilised as a multipurpose community facility all through the year so as to avoid deterioration of the building by not using it during non-cyclone periods. Therefore, the design consideration will keep in mind its use for multiple purposes such as school, ration shop, community centre, teaching centre, temporary godown or a public utility building. Constant use of the building for various purposes ensures that it is well maintained at all times and, consequently, it becomes available during a cyclone, which is its main purpose. It also generates income for its maintenance.
- ii) Cyclone shelters will be located preferably about 1.5 km away from the coast. The shelter will be located near a school or preferably within a school premises for a cluster of villages. Alternately, it will be located as a community facility for the cluster of villages.
- iii) The plinth height of 1.5 m will be used for stilt with the height varying from 2.5 m to 4.5 m if the storm surge level is more than 1.5 m and less than 4.5 m. In all cases, the floor level of a shelter will be at least 0.5 m above the possible maximum surge level.

- iv) A sloped ramp will be provided in case the surge level exceeds 1.5 m.
- v) The cyclone shelter will be designed with RCC frame and laterally supported filler walls.
- vi) The foundation will be taken to a depth equal to that of the surge level to avoid scouring, subject to a minimum of 1.5 m.
- vii) The shelter will have a rectangular or polygonal plan depending on the functional aspect, with curved corners for better aerodynamic features and the non-erosion of walls. A rectangular plan with curved corners is more functional for many aspects.
- viii) An overhead RCC water tank with reasonable storage capacity will be provided over the shelter roof or as an independent tank at an elevated level nearby.
- ix) Rainwater harvesting techniques will be adopted to augment water supply to the shelter.
- x) The flooring will be of polished stone to be able to withstand weathering and, thereby, reducing maintenance costs.
- xi) Adequate toilet and bathing facilities will be provided in accordance with the existing government standards. The toilet and bathroom fittings will be either GI or aluminium. The walls of the toilets/bathrooms will be fitted with glazed tiles, for minimum maintenance. However, a minimum number of toilets will be provided as per the holding capacity of the shelter.
- xii) Solar panels will be used for heating water and supply of electricity, wherever possible.

#### 4.2.4 Construction of New Building Structures

4.2.4.1 Construction of new buildings will follow the standard code of Gol. The selection of sites will be based on a study of 100-year return period TC, wind and other climatic parameters and earthquakes, wherever applicable, so that vulnerability is reduced.

4.2.4.2 New cyclone shelters will be planned for multi-purpose use. Further, it will be ensured that other structures like schools, community halls, places of worship, etc., meet all the prescribed standards required to withstand the fury of cyclones, and also serve as shelters if the need arises. In some states like Andhra Pradesh, community halls are being constructed for fishermen, in villages with predominant fishermen population, which could be used as cyclone shelters as and when required. It will be ensured that even these community halls meet the prescribed standards for MPCS.

4.2.4.3 Regarding the construction of private houses, the local community will be encouraged to construct houses which would be cyclone resistant. ULBs and PRIs will also ensure this.

#### 4.2.5 Maintenance of Cyclone Shelters

4.2.5.1 MPCS or any safe shelter needs regular maintenance and timely repairs according to the need of the structure, so as to keep them ready for occupation in the event of a cyclone. However, budgetary provision for the maintenance of MPCS is generally lacking. Further, there are also instances of allocations made in the budget not being utilised. States and UTs will not only make adequate provision for maintenance but also ensure full utilisation of the same. This will be possible with periodic monitoring. Assessment of the conditions of existing cyclone shelters by the line departments has to be conducted periodically.

4.2.5.2 Some states have set up monitoring committees consisting of representatives of the state government/ULBs/PRI/NGOs and leaders of the community. During normal periods, MPCSS can be put to use for the community as *anganwadis*, schools, community centres and even for social gatherings, by charging a suitable user fee which can be used for maintenance.

4.2.5.3 Involvement of the community in locating, planning and proposing general purpose usage ensures ownership and maintenance of these assets. The following measures will be envisaged for proper and effective maintenance of MPCSS and other safe shelters:

- i) Ensure multi-purpose use of the shelters.
- ii) Collect a suitable maintenance fee from the users by lending them for use for social functions; use the money thus collected, to set up a corpus fund. Besides, budgetary allocations may be made for the maintenance of these shelters. A corpus fund may be set up with the budget provision as seed money for a corpus fund that could be set up and maintained by the village panchayat and subject to Local Fund audit.
- iii) Schools, community halls and places of worship that are used as safe shelters at the time of cyclones will be maintained by the local communities.

#### Maintenance of Cyclone Shelters

- i) States and UTs will make adequate provision for maintenance of shelters and ensure full utilisation of the same.
- ii) Periodic monitoring and assessment of the conditions of existing cyclone shelters by the line departments has to be conducted and this has to be coordinated by DM departments.
- iii) Multi-purpose use of shelters will be ensured.

iv) Schools, community halls and places of worship that are used as safe shelters during cyclones will be maintained by local committees with assistance from the government.

v) Shelters will be provided with amenities such as drinking water facility, bath and toilet facilities for large gatherings for a few days, during disasters.

### 4.2.6 Government Housing Programmes

4.2.6.1 Large housing programmes, like the Indira Awas Yojana 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.

Planning and implementing agencies, including NGOs, will obtain clearance for housing schemes, including selection of sites, from the competent authority before taking them up in cyclone-prone coastal areas, for which the district authorities will lay down clear guidelines to ensure that all DM norms are followed.

### 4.2.7 Amenities

4.2.7.1 Cyclone shelters will be provided with amenities for large gatherings for a few days during the disaster. Separate storage tanks are proposed for drinking and general purpose usage, to be placed on the roofs of the kitchen and toilets. Rain

water harvesting will also be planned to collect rain water from roof tops and stored appropriately for general purposes, drinking and cooking. Arrangements for simultaneous filtration by sedimentation and chlorination of the water will be planned before storing the water in tanks.

4.2.7.2 Water connection from a regular public water supply scheme, if functioning in the habitation, will also be provided and connected to the sump in ground floor with a provision for pumping to tanks on roof tops—in the normal course and also prior to occupation in case of a cyclone warning. Bore wells with specially designed elevated hand pumps will be provided near the shelters, wherever necessary.

#### 4.2.8 Retrofitting of the Damaged or Deteriorated Existing Public Infrastructure

##### 4.2.8.1 Structural Damage due to Cyclones

As has been discussed earlier, cyclones affect all types of buildings—non-engineered buildings such as thatched roofs, semi-engineered buildings such as workshop buildings and storage godowns, and even well-engineered buildings and structures such as communication towers, etc.

4.2.8.2 Low-rise Buildings (LRB)/structures form part of major portions of the construction industry. Unfortunately, these are most affected and damaged during any cyclone. LRBs are assemblages of wall and roof elements which in turn have sub-elements such as rafters, purling and cladding. Thus, the weakest link decides the strength of the building. Most of the failures have been observed only due to lack of one of the following design/construction aspects: anchorage, bracing, connections or detailing. Hence, retrofitting of a damaged low-rise building will receive special attention with regard to the above principle and, more desirably, be carried out on a case-by-case

basis. Different types of materials are used for the walls and roofs and, depending on their strengths, the performance of a building varies widely during a cyclone.

#### Improvements in materials and methods of construction for better resistance to cyclones

- i) Houses with thatched roofs and mud walls, being constructed extensively in coastal regions, have inadequate resistance to high cyclonic wind forces and the collapse of such houses is expected during cyclones. It is suggested that their use in construction of new houses will be avoided as far as possible.
- ii) The building layout, type of roof and positioning of openings also influence the building's performance during a cyclone. The blowing off of thatched roofs will be prevented by tying the roof with rope, wire or metal straps and by anchoring it to the ground.
- iii) The durability of the mud walls will be improved by waterproof treatment of the exterior and interior surfaces. Use of non-eroding mud, based on bitumen cutback will be encouraged.
- iv) It is reported, based on wind tunnel investigations, that when the pitch of the roof ranges between 30 and 40 degrees, the wind force on the roof cladding is minimal. Hence, to construct the roof with pitch ranging between 30 and 40 degrees will be encouraged.
- v) Pitched roof buildings with both hip and gable types are normally constructed in the coastal regions for residential and other low-rise industrial structures. However, it has been observed in many post-disaster cyclone damage surveys that hipped roofs survived better than gabled roofs, a fact which has also been substantiated by the wind tunnel experiment.

#### 4.2.8.3 Anchorage, Bracing and Continuity

Anchorage, bracing and continuity are the prime factors influencing structural integrity. These imply that, every part of a structure is firmly tied or anchored back to a secure point which can safely resist all the forces acting on it. Roof and walls are properly braced to prevent tilting, sliding and rotation and every part of the structure is properly connected to every other member along the 'strength chain' from cladding to foundation.

The following practices will be adopted to achieve this:

- i) Conventionally used J bolts for connecting the cladding sheets to rafters/purlins are found to be ineffective in resisting uplift cyclonic wind forces. By providing U bolts in place of J bolts at closer intervals, the flattening of J bolts and its consequent weakening of the connections will be prevented. Galvanised U hook bolts of 6 mm diameter with suitable nuts, diamond-shaped curved metal washers, and bituminous or rubber under-washers are recommended for fixing the AC cladding sheets. The number and spacing of the hook bolts will be of symmetrical nature.
- ii) A typical characteristic of the wind flow over a LRB is that the uplift on the roofs outweighs the dead loads due to roof materials leading to failure. Hence, in the case of roofs with tile cladding, by providing concrete restraining strips over the tiles the dead load of the cladding unit can be increased, which is beneficial in resisting the uplift forces. The spacing of these strips will be 1.5 m which will be reduced to 1.2 m near the gable ends. Further, these strips will be tied to the main rafters by tying down the reinforcing bar provided in the concrete strip, using 30 x 24 mm gauge GI straps and 50 x 12 mm gauge nails.
- iii) In the case of masonry walls, in the majority of houses constructed in India, a continuous band of reinforced concrete beam is provided at plinth level to take care of differential settlement. When the soil conditions are poor, a bond beam is also provided at the lintel level. Floor and roof slabs of reinforced concrete provide adequate restraint to the masonry walls at the top.
- iv) Reinforced bond beams will be provided in shed-type structures at the top to increase their lateral resistance of the wall to resist high wind forces. Also, provision of anchorage in the form of tie-down bolts between the foundation and bond beam is essential for further improving the resistance against cyclonic forces.
- v) The failure of a large number of gable or side walls in low-rise industrial buildings was observed during cyclones, and it was mainly due to inadequate lateral resistance of the wall to resist high wind forces. By reducing the spacing of pilasters and by providing a continuous RC bond beam at the top, the lateral resistance of the wall will be improved. Provision of RC columns to support the roof trusses (instead of brick pilasters) with in-filled brickwork will increase the lateral resistance of the wall. This also helps in restricting the extent of damage to the panels only, in the event of a failure due to cyclone, thereby preventing the progressive collapse of the roof truss system.
- vi) The integrity of the structure in resisting the cyclonic forces will also be improved by providing suitable roof bracing between the trusses. The resistance of free-standing compound walls to lateral high wind forces will be improved by either staggering the walls and/or by reducing the spacing of the brick plasters or RC pillars or by tying down the wall to the foundation using tie-down bolts at suitable intervals.



4.2.9 Inspection and measures for assured usage and maintenance scheme for shelters

- i) Periodic inspection will be made by an engineer before and after the rainy and cyclone seasons.
- ii) The inspection will look into the water supply, drainage, accessibility to the shelter, etc.
- iii) A copy of the inspection report will be sent to the state/district DM department which would ensure the maintenance needs and the compliance of repair work.

#### 4.2.10 Cattle Mounds

4.2.10.1 Cattle mounds have to be located in close proximity to cyclone shelters. Every habitation needs a suitably designed cattle mound. The level of the mound has to be higher than the ground level. Once the location of a cattle mound is identified, efforts will be made to raise the ground level appropriately. Dismantled building materials and excavated material can be dumped at the cattle mound. The primary requirement is a high ground level for the cattle and if possible a suitable roof may be provided.

Efforts will be made to have cattle mounds adjacent to cyclone shelters. Selection of sites for cattle mounds will be made immediately along with the site for the MPCS. Efforts will be made to raise the level of the site selected for the cattle mounds to the final extent required, keeping in view the maximum storm surge, by using debris or earth from sites which have been excavated.

### 4.3. Road Links, Culverts and Bridges

4.3.1.1 A 25 km band of the coastal stretch may be taken as most vulnerable to cyclones, with some scope for variation because of local topography and other factors. It has been observed that many of the coastal villages do not have all-weather approach roads. The objective will be to ensure all-

weather access roads are provided to all habitations/villages falling within this area in all the 84 coastal districts of the country.

4.3.1.2 There will be a regular mechanism to review the conditions of roads, culverts and bridges for every quarter or pre- and post-cyclone season/monsoon period by the DM departments of the states/UTs.

4.3.1.3 A reliable road network connecting vulnerable areas to select nodal centres from where transport, relief and rehabilitation operations can be coordinated in the event of a natural disaster will be an essential preparedness measure.

#### 4.3.2 Restructuring of Link Roads to the Shelters

4.3.2.1 Effective road connectivity ensures fast deployment of men, materials and machinery to affected areas and also ensures speedy evacuation of people from vulnerable places to safer areas in the face of an impending disaster. The condition of link roads to existing cyclone shelters in such times is crucial for the evacuation of people. Hence, there is a need for the development of a reliable road network with all-weather accessibility in the vulnerable areas to ensure easy access to the shelters for effective evacuation, coordination of relief and response in the event of a cyclone.

4.3.2.2 Roads/culverts/bridges in the cyclone prone areas need to be well maintained and given utmost attention. Roads are always associated with culverts and bridges as the terrain demands, and routine maintenance of these structures is crucial for post-cyclone response. Concrete buildings, mainly in the coastal region, are most vulnerable to reinforcement corrosion. Bridge foundations in alluvial soils lead to deep scour near some piers when large discharges of flood waters due to cyclonic storms occur, which may result in tilting of foundations and consequent distress to the bridge

deck. Where the general road condition is found to be bad due to poor sub-grade and the bridges and culverts are in a distressed condition, their restoration work has to be accorded high priority. Repair and retrofitting work is a specialised job and requires the use of special materials and expertise. Before taking up the work, one has to complete visual inspection, find the causes of distress, establish the degree of distress through relevant tests, and work out the appropriate remedial measures to be taken.

#### Design Considerations for Roads, Culverts and Bridges

- i) Efforts will be made to provide at least one link road for each village that is accessible even during the cyclone and flood inundation periods.
- ii) The link road and the culverts on the road will be with requisite hazard resistant structural design specifications and planning.
- iii) Each link road to the village and to the shelter will be identified and marked for mandatory maintenance as per the requirement.
- iv) The link road and culverts will be designed and laid with road level 0.5 m above the possible flood level.
- v) Embankment of the road will be well protected, preferably by revetment.
- vi) The sub-grade and the main course of the road will have the same specification as that of a national road so as to be durable under hazard conditions. It will be at least a single lane of about 4m width with adequate camber (preferably a gradient of 1 in 15) for allowing quick drainage.
- vii) The link road that leads to a shelter will have to be laid in M30 grade concrete.
- viii) Bridges and culverts will be designed with RC slabs as per IRC recommendations. The minimum width of the culvert will be for two-lane traffic even if the road is of one lane.

- ix) M30 grade concrete and Fe 415 reinforcement steel will be used in all the culverts of the link road. Similarly, all materials used in the culverts and roads are to be tested as per IS specifications.

#### Inspection and Maintenance Measures for Link Roads, Culverts and Bridges

- i) In the case of a link road to a cyclone shelter, inspection will be made by an engineer both before and after the rainy season. A copy of the inspection report will be sent to the state DM department for follow-up action. The report will contain a plan of action for repair or maintenance needs.
- ii) Action taken for the compliance of repair work will also be sent to the state DM department.
- iii) The maintenance required for concrete roads is much less as compared to bitumen carpeted roads. However, embankment scouring will cause damage to the road, and attention will be given to this aspect.
- iv) Drainage away from the road will be ensured. Further, culvert clearance before the monsoon is necessary.
- v) The inspection/condition survey of bridges and roads is to be carried out in accordance with IRC: SP: 18-1978, 'Manual for highway inspection'.
- vi) Routine, principal and special inspections are to be carried out by a competent authority using conventional tools as indicated in IRC: SP: 35-1990, 'Guidelines for inspection and maintenance of bridges'.
- vii) Culverts and bridges which exhibit distress through strains, cracks, spalling etc., during inspection, will be kept under observation and detailed records of the action taken to rectify the defects will be made available for future inspection and maintenance work.

## 4.4 Canals, Drains, Surface Water Tanks

4.4.1.1 The coastal areas usually have tidal creeks, river mouths with natural delta formation and a network of canals and drains – both natural and man-made, except where there is a hilly terrain. The network of canals and drains as also the river mouths have very significant effect in alleviating the impact of cyclone by receiving, accommodating and returning back surge waters to the sea. However, these are usually very badly neglected. Canals and drains get choked by weeds, silting, sand and encroachments. These remain unattended for decades together, sometimes for over a century.

4.4.1.2 The main drains and canals are fed by primary and tertiary canals. Standard Operating Procedures (SOPs) have to be put in place in respect of their maintenance in totality. Their condition has to be assessed periodically, particularly in the pre-disaster and post-disaster seasons. It may be necessary to widen drains or even have diversion canals, wherever required, to cope with flooding due to heavy rains associated with cyclones and storm surges. It may be noted that surface water tanks also serve to lower the impact of cyclones and storm surges. But poor maintenance of these tanks lowers their storage capacity due to silting. Therefore, it is essential that desilting of surface water tanks is regularly undertaken.

### 4.4.2 Restructuring for Over-Flooding

4.4.2.1 In the deltaic areas, surface communication is a major handicap for post-cyclone response activities. In flat terrains, intertwining of rivers and rivulets is quite common. The widths of the tidal rivers are linked to the sea tide and may not have a stable embankment. This makes it difficult to construct bridges on these rivers. A coastal canal system serves as an alternative to road communication. Improvement of minor drains

in the coastal areas is also required for effective drainage of water and flood embankment works.

4.4.2.2 It will ensure the expected functionality of canals/drains in acting as shock absorbers for flood waters and its force during a cyclonic event. As a consequence of this, the prospect of inundation of agricultural fields, villages and roads is diminished completely or at least to a manageable level. This further ensures easy access to vulnerable villages as road inundation is reduced.

#### Design and Maintenance Considerations for Canals, Drains and Tanks

- i) The reinforcement cover of the foundations, substructure locking gates/sluices will be at the level specified in IRC: SP: 33-1989 to achieve the expected level of durability. For steel structures, IS-800 will be followed.
- ii) To ensure proper functioning of canals/drains/tanks during storm surge due to cyclone, the following measures are required:
  - a) Branches to the canal drain are to be closed.
  - b) The embankments will be strengthened.
  - c) The condition of the passage-bridge and channels will be checked.
  - d) Obstructions in the canals/drains will be removed periodically to enable free flow of water.
  - e) The blocks and shutters of the canals are to be checked for satisfactory performance.
  - f) The instruments and materials required for attending to immediate repairs, breach of closures, etc., will be stacked in advance at places where they may be required.
  - g) Navigation in the canal will be stopped.



- h) Water supply into canals will be cut out off by closing the sluices.
- i) The canals and drains will be free from constructions and they will be made available for free discharge of drain water.
- j) The link drains will be lined to minimise maintenance and overflowing during the monsoon.
- k) The water tanks used for drinking water supply are likely to become saline and will even get contaminated during a cyclone. Adequate embankment of at least 0.5 m above the flood level will be provided to such tanks.
- l) The growth of water hyacinth, etc. is a major problem in many areas as they obstruct and affect the carrying capacity of drains, canals and tanks. A regular maintenance mechanism will be institutionalised.

## 4.5 Saline Embankments

4.5.1 Coastal areas are generally densely populated. It is estimated that about 32 crore people, which accounts for almost a third of the country's total population, are vulnerable to cyclone related hazards. These areas are vulnerable to inundation of various degrees depending upon the frequency of cyclone, coastal bathymetry and coastal inland topography of the place. Cyclone-related rainfall and storm surges are mainly responsible for such coastal inundation that at times cause enormous loss of life and property. Construction of 'saline embankments' is one of the structural mitigation measures to protect habitation, agriculture crop and important installations along the coast. The protection of coastal areas by constructing saline embankments is already in vogue in most of the maritime states. For instance, Orissa had a total of about 1517 km of saline

embankments before the super cyclone of 1999, which were severely damaged by that cyclone. West Bengal (3500 km embankments) and other states also had saline embankments constructed along their coast in the past.

4.5.2 These embankments are designed to protect the coastal population and property from regular phenomena such high tides, low intensity cyclone and normal rainfall but, are not adequate or suitable to protect the coast from high intensity cyclones generating high surge. Moreover, existing embankments frequently get damaged and are destroyed due to regular impact of tides and weather and inadequate maintenance. Properly designed saline embankments need to be constructed after detailed survey of existing embankments and assessing vulnerability and requirements. Regular maintenance of such embankments needs to be institutionalised.

- (i) States/UTs will carry out detailed survey of the requirement of saline embankments along their coastal areas and construct suitable embankments to protect vulnerable areas in a phased manner, as per the priority.
- (ii) Repair of saline embankments will be carried out as per Bureau of Indian Standards (BIS) and CWC standards. For embankments, IS -1786 is followed.
- (iii) Suitable guidelines will be prepared for the construction of saline embankments along the Indian coast.
- (iv) A mechanism for the regular maintenance of saline embankments will be institutionalised by the respective states/UTs.

## 4.6 Communication Towers and Power Transmission Networks

4.6.1.1 The coastal areas are generally endowed with a large network of communication and power transmission lines in keeping with the comparatively

higher requirement. Lessons have to be learnt from past experience of devastation due to cyclones in different states.

4.6.1.2 Communications and power transmission towers will be designed on the basis of 100-year return period wind velocity of cyclone.

4.6.1.3 Establishing Communication Rooms for last mile connectivity

4.6.1.4 It is necessary to establish fail-safe communication rooms in all cyclone shelters and other identified relief/rehabilitation centres (schools, community halls and places of worship, etc.) as a part of last mile connectivity for receiving early warning messages and for organizing necessary relief and rehabilitation efforts.

#### 4.6.2 Retrofitting or Strengthening of Deteriorated Towers

4.6.2.1 Communication and power transmission line towers are considered to be well-engineered structures since they receive good engineering attention right from the planning to the design and execution stages. Nevertheless, some failures of such well-engineered structures do occur during severe cyclones, as has been observed during post-cyclone damage surveys conducted after the Kavali (1989) and Kakinada cyclone (1996) in Andhra Pradesh, the Gujarat cyclone (1998) and the super cyclone (1999) in Orissa.

4.6.2.2 These structures are referred to as 'repeated structures', as they are designed and constructed in large numbers. When failures occur, all the primary and secondary members of the towers are twisted and bent totally and brought to the ground, such that retrofitting is seldom feasible. The entire structure has to be rebuilt. Hence, considering the socio-economic importance of the structure in the event of a failure, it is highly desirable that the design of a communication and

transmission line tower, including its foundation, is checked by a competent authority.

4.6.2.3 Further, through regular inspection for assessing the conditions of the sub-assemblages such as cables and other fixtures in case of transmission line towers and antennas in case of lattice communication towers, the development of fatigue cracks can be checked and monitored.

#### Design and Maintenance considerations of Communication and Transmission Line Towers

- i) Transmission line and communication towers and elevated water tanks located in the cyclone prone areas will be designed with wind speed 1.3 times that specified by IS: 875/(part 3)/1987. The open area in the zone and its topography will be given due consideration in selecting the correction factors.
- ii) The towers will be designed using their dynamic analysis with suitable wind gust loading.
- iii) The structural steel used in the towers will be galvanized to withstand the corrosive exposure condition.
- iv) The foundation depth will be taken at least 1 m below the scour level and the stability of the towers will be standalone without depending on the filling weight of the soil.
- v) The design of a communication/transmission tower, including its foundation, is checked by a competent authority.

#### 4.7 Relevant IS codes

4.7.1 Various BIS codes are already developed, which will be referred to for the construction of different structures such as cyclone shelters, embankments, roads, bridges, canals, drains, transmission towers, etc.

**The relevant BIS Codes are:**

- i. IS 456 : 2000 Plain and Reinforced Concrete – Code of Practice (reaffirmed 2005).
- ii. IS 875 : Part 3 : 1987 Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads (reaffirmed 2003).
- iii. IS 800 : 1984 Code of practice for general construction in steel (reaffirmed 2003) IS 8237 : 1985 Code of Practice for Protection of Slope for Reservoir Embankment (reaffirmed 2002).
- iv. IS 10635 : 1993 Freeboard requirements in embankment dams – guidelines (reaffirmed 2003).
- v. IS 11532 : 1995 Construction and maintenance of river embankments (levees) – guidelines (reaffirmed 2005).
- vi. IS 12094 : 2000 Guidelines for Planning and Design of River Embankments (Levees) (reaffirmed 2005).
- vii. IS 12169 : 1987 Criteria for design of small embankment dams (reaffirmed 2002).

**4.8 Major Action Points**

1. A robust system of locating cyclone shelters and cattle mounds will be established based on the vulnerability profile of the regions along with the prescribed structural safety standards. Necessary mechanism will be built to account for the basic needs and maintenance requirements along with special design considerations (refer sections 4.2.2, 4.2.5, 4.2.7 to 4.2.10).  
[Action: SDMAs, State Government Engineering Departments]
2. The structural safety of lifeline infrastructure will be made the centre stage of disaster risk reduction with the mandatory techno-

legal support framework based on the Indian Building Codes and Standards and IRC Specifications (refer sections 4.2.3, 4.2.4, 4.2.8).

[Action: BIS, Ministry of Urban Development, SDMAs/DDMAs, Local Authorities, Area Development Authorities, Engineering Departments of the Coastal States/UTs, etc.]

3. Local communities will be encouraged to follow prescribed cyclone resistant structural design standards for construction of private houses (refer section 4.2.4.3).

[Action: States/UTs, ULBs/PRI]

4. The following maintenance aspects of cyclone shelters and other safe places at the ULB/PRI level will be institutionalised:
  - i) Making adequate provision for maintenance of shelters by states and UTs and ensuring its multi-purpose utilisation (refer section 4.2.5).
  - ii) A periodical assessment system of the conditions of existing cyclone shelters by the line departments (refer section 4.2.5).
  - iii) Adequate maintenance arrangements for schools, hospitals and places of worship by the local committees with the assistance of the government (refer section 4.2.5).
  - iv) Making adequate provisions of amenities in cyclone shelters such as drinking water, bathing and toilet facilities for large number of people during the disaster phase taking into consideration requirements of women, children, aged and physically challenged people (refer section 4.2.7).

[Action: State Governments/UTS, ULBs/PRI]

5. Cyclone resistant design standards will be incorporated in the rural housing schemes like the Indira Awas Yojana (IAY) and Jawaharlal Nehru National Urban Renewal Mission (JNNURM) projects planned for coastal urban areas (refer section 4.2.6).

[Action: Ministry of Rural Development, Ministry of Urban Development, Local Area Development Authorities]

6. Housing schemes under different central/state government programmes will obtain clearance from competent authorities, who will take into consideration all DM related aspects (refer section 4.2.6.1)

[Action: States/UTs, ULBs/PRIs]

7. All-weather road links will be built to all coastal habitations, between habitations and cyclone shelters/cattle mounds covering all 84 coastal districts vulnerable to cyclones, along with a regular mechanism to review the conditions of critical road links, culverts and bridges every quarter (refer section 4.3).

[Action: Ministry of Rural Development, Ministry of Engineering

Departments of State Governments/ UTs]

8. Full carrying capacity of main drains and canals, along with feeder primary/secondary/tertiary channels will be maintained. In addition, drains will be widened for additional carrying capacity (refer section 4.4).

[Action: CWC, State Irrigation Departments, Command Area Development Authorities, Local Area Development Authorities]

## 4.9 Implementation Strategy and Time-Frame

### 4.9.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

### 4.9.2 Following is the time-frame for implementation of activities listed in this chapter.

#### Time-Frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commencement	Action and Date of Completion
1	Establishment of structural safety plan with the techno-legal framework for cyclone resistant design standards	MoUD & PA, BIS, SDMAs	2008-09	2009-10
2	Guidelines for locating cyclone shelters, coastal embankments and cattle mounds	SDMAs, BIS, Coastal Area Development Authorities	2008-09	2009-10
3	Incorporation of cyclone resistant structural design standards in coastal area projects of IAY and JNNURM	MoUD & PA, BIS, SDMAs	2008-09	2011-12
4	Build all-weather road links for coastal habitations, cyclone shelters/cattle mounds	SDMAs, BIS, Coastal Area Development Authorities	2008-09	2011-12
5	Sustaining carrying capacities of coastal drains, canals, feeder channels, carrying capacity enhancements/additional flood flow canals	SDMAs	2008-09	2011-12

# 5

## Management of Coastal Zones

### 5.1 Overview

5.1.1 Coastal areas are endowed with a wide range of coastal eco-systems, which are characterised by distinct biotic and abiotic processes. Coastal areas are also places that experience natural hazards like floods, cyclones and tsunamis. While it is not humanly possible to prevent or even control these phenomena, a holistic approach to Coastal Zone Management (CZM), including precautionary measures like proper planning of the coastal areas for locating communities and infrastructure in safer areas, protecting and restoring natural bio-shields etc., can minimise loss of life and damage to property to a considerable extent. Such measures have to be truthfully addressed with the participation of all stakeholders.

### 5.2 Coastal Zone Management Issues

5.2.1 A combined approach to coastal protection and resource conservation simplifies the process of management and leads to more balanced decisions on what constitutes acceptable development. The setback requirement that protects beachfront structures from erosion and storm waves can also preserve turtle-nesting sites on the back beach. Similarly, restriction on clearing of mangrove swamps will not only conserve an economically valuable resource, but also maintain a physical defence against storm tides. Severe beach erosion is a problem of all coastal nations.

#### 5.2.2 Assessment of Shoreline Changes

5.2.2.1 The coastal environment comprises several ecological features. Their characteristics were

studied in 1992 by the Space Applications Centre (SAC), Ahmedabad, with the objective of mapping the Indian coast on a 1:250,000 scale using satellite data. The mapped shoreline change between 1973-75 and 1985-86, and the identified problems of coastal wetlands triggered government initiatives to preserve coastal eco-systems.

#### 5.2.3 Conservation of Coastal Wetlands

5.2.3.1 Vegetated and non-vegetated wetlands (freshwater, coastal marshes, swamps, mangroves, waterlogged areas) are converted for aquaculture, salt pans, agriculture and even for housing/tourism/industry, etc. Non-vegetated wetlands are potential zones for the expansion of bio-shield belts that can also meet the requirements of local communities in terms of fuel wood and timber, following its regeneration cycle. Plantation of mangroves can be initiated in the inter-tidal areas after considering their suitability and adaptability to the species to be planted. Some of the non-vegetated wetlands include past degenerated mangrove zones as well. The reclamation of backwaters is a serious problem in coastal Kerala and a plan will be prepared to conserve these backwaters. The scenic coastal sand dunes and sandy beaches can be well stabilised by adopting suitable afforestation programmes. Cashew and casuarinas are found to be promising shelterbelt plantations on the shoreline. Hence, natural/organised bio-shield plantation efforts need to be given priority in coastal wetlands.

5.2.3.2 The basis for conservation of wetlands has been established in two important studies carried out by SAC, Ahmedabad, and the National Remote

Sensing Agency (NRSA), Hyderabad, through firming up of methodologies for zoning dominant varieties of mangroves using satellite data. While the SAC study is found to be useful in getting information on dominant mangrove community zones, the NRSA study made it possible to delineate the areas up to 50-100 ha, along with biodiversity characterisation at landscape level over the eastern coast only, at 1:50,000 scale.

- i) Mapping will be carried out at 1:25,000 scale for delineation of entire coastal wetlands including beach vegetation, bio-shields, sea grass, opening of lagoons in certain cases and small islands, etc., on priority using IRS LISS IV data to delineate small patches (<20 ha) of mangroves and shelterbelts besides identifying new areas for coastal bio-shield expansion.
- ii) Monitoring of delineated and new areas of coastal bio-shields will be carried out using CARTOSAT I/II satellite images on an annual basis for containing degradation, preservation of natural coastal barriers such as sand dunes, mudflats/banks, sandbars, estuaries and cliffs, etc., and to ensure their regeneration/preservation.
- iii) A National Wetland Biodiversity Register, along with an inventory of 'user groups', will be started. The economic evaluation of wetlands will be carried out and integrated with National Resource Accounting.
- iv) Wetland productivity studies will be undertaken on a long-term basis by identified organisations from different parts of the country.

#### 5.2.4 Geomorphic Characteristics of the Coastal Eco-systems

5.2.4.1 Geomorphic characteristics refer to physical changes driven largely by natural phenomena over longer time-scales, some of them being decadal. While careful assessment of coastal

changes must form the cornerstone of effective coastal management, it is often insufficient to monitor sequential variations without paying due regard to the causes of change. Knowledge of these causes would obviously assist attempts at stabilisation. The ability of coastal environment to buffer human induced/natural impacts (hazards and climate change) is crucial for the sustainability of the biodiversity and productivity of coastal zones through a holistic and trans-sectoral management approach. The need of the hour is to facilitate the preparation of well-coordinated land-use project plans, vulnerability zoning and site development plans through multidisciplinary teams.

5.2.4.2 The Indian coastline is marked with a variety of geomorphological features, namely tidal flats off the Gujarat coast, flat beaches of Goa and a few regions of Maharashtra and Karnataka, mud banks of the Kerala coast, presence of a large number of outcrops, particularly of the Tamil Nadu coast, at the southern tip of the Indian peninsula. Net sediment transport varies from the east coast to the west coast, and on the east coast this activity is associated with the cyclone season while on the west coast, it is associated with the occurrence of monsoons. The net drift is to an extent of about 106 m<sup>3</sup>/annum. This quantity of sediment transport is probably the largest in the world and it is a challenge to coastal engineers, planners and managers. The general problems along the Indian coast are:

a) Silting of entrance channels; b) Closing of river mouths; c) Problems concerning aquaculture; d) Silting of intake structure; e) Inland inundation; f) Sandbar formation near the mouth of inlets, rivers and estuaries and g) Erosion of the coast.

- i) Top priority will be given to coastal protection as it is extremely important even for the fixing of the high tide line.
- ii) Structural measures may be taken up only if soft non-structural measures are not possible to be adopted. While considering structural measures, particularly for groins



Table 5.1 Geomorphic Characteristics of Coastal Eco-systems

Sl. No.	Functionality of the Geomorphic Eco-sensitive Barriers	Threats	Management Options for Enforcement
1.	<p style="text-align: center;"><u>Beaches</u></p> <ul style="list-style-type: none"> <li>• Buffer against coastal erosion</li> <li>• Habitats for many plants and animals</li> <li>• Spawning ground for turtles</li> <li>• Energy base to support the diverse population of deposit and filter-feeding organisms</li> <li>• Energy sources for coastal birds and fish</li> <li>• Aesthetics</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial citing</li> <li>• Sand mining</li> <li>• Development</li> <li>• Engineering structures that affect coastal erosion/ accretion, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Demarcate setback line for development control</li> <li>• Plan for sand bye-pass system/replenishment</li> <li>• Allow beach cycle to return and after cyclone passage</li> <li>• Adapt sustainable multiple uses</li> </ul>
2.	<p style="text-align: center;"><u>Sand Dunes and Bars</u></p> <ul style="list-style-type: none"> <li>• Sand reserve for protection and stability of the coast</li> <li>• Shelter for supply and recharge of fresh water aquifer</li> <li>• Habitat for several plants and animals</li> <li>• Important tourism and recreational resource</li> <li>• Shield for living behind the dunes from tidal surges and large waves such as the tsunami waves</li> </ul>	<ul style="list-style-type: none"> <li>• Mining for minerals and construction</li> <li>• Levelling for construction of beach resorts and economic activities</li> <li>• Road, rail and other infrastructure development</li> </ul>	<ul style="list-style-type: none"> <li>• Conservation of fore dunes and preservation of rear dunes</li> <li>• Develop artificial dunes and stimulate dune growth</li> <li>• Restriction of sand mining by promoting usage of alternative materials for construction</li> <li>• Redefine setback lines for beach resorts and industries</li> </ul>
3.	<p style="text-align: center;"><u>Earth/Rocky Cliffs and Rocky Foreshores</u></p> <ul style="list-style-type: none"> <li>• Barriers against strong winds, cyclonic storm surges</li> <li>• Anchorage for many types of algae and mussels</li> <li>• Habitat for different crabs and molluscs</li> <li>• Aesthetics</li> </ul>	<ul style="list-style-type: none"> <li>• Urban use of cliff-top land</li> <li>• Extraction for minerals and other uses</li> <li>• Development affects landscape stability</li> <li>• Environment and climate change impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Despite ban on mining, extraction, etc. in CRZ areas, these features are under continuous threat</li> </ul>

<p>4.</p>	<p><b><u>Estuaries, Lakes and Lagoons</u></b></p> <ul style="list-style-type: none"> <li>•Spawning, nursery and feeding ground for clams and mussels and sea grass beds</li> <li>•Sites of mangrove, marsh stability, shifts sediments, creates mudflats, controls coastal stability</li> <li>•Controls salinity and nutrients transport</li> <li>•Cleanses the system by flushing away waste products</li> <li>•Absorbs wave energy and floods/surge inundation</li> </ul>	<ul style="list-style-type: none"> <li>•Reclamation for development</li> <li>•Municipal and industrial waste disposal</li> <li>•Reduction and prevention of freshwater inflow (natural or man-made)</li> <li>•Dredging of waterways and tampering natural upstream land drainage systems through unregulated watershed development</li> </ul>	<ul style="list-style-type: none"> <li>•Limit reclamation for essential activities based on the feasibility of eco-system sustainability</li> <li>•Allow disposal of treated waste in to upstream land drainage channels to ensure minimal fresh water inflow to maintain eco-system balance</li> <li>•Ensure sufficient tidal exchange</li> <li>•Quantify and monitor waste treatment levels based on the assimilative capacity in support of critical habitats</li> <li>•Address land use conflicts through zoning of potential areas for aquaculture, salt production, ports, tourism and infrastructure projects based on circulation system studies and carrying capacity estimates</li> <li>•Relocate existing/avoid locating chemical plants with toxic discharges</li> </ul>
<p>5</p>	<p><b><u>Mud/Tidal Flats</u></b></p> <ul style="list-style-type: none"> <li>•Nurture large populations of several species of birds and other fauna.</li> <li>•Flood plains controlling floods</li> <li>•Sediment source for the shore stabilization</li> </ul>	<ul style="list-style-type: none"> <li>•Reclamation for development</li> <li>•Municipal and industrial waste disposal and effluent discharge</li> </ul>	<ul style="list-style-type: none"> <li>•Limit reclamation based on feasibility of eco-system sustainability</li> <li>•Allow discharge of treated flow (free from toxicity and turbidity) from municipal and industrial sources</li> <li>•Restrict dumping of dredged soil</li> <li>•Zoning for uses to ensure sustainability</li> <li>•Ensure enough amount of sediment-laden water inflow from sea side to sustain fertility of mud flats</li> </ul>

<p>6.</p>	<p><u>Deltas, Salt Marshes and Tidal Inlets</u></p> <ul style="list-style-type: none"> <li>• Barriers to tide, wind and wave actions</li> <li>• Sites of mangrove, marsh and sea grass beds</li> <li>• Highly productive agriculture, aquaculture, salt production and several economic activities</li> <li>• Sustain brackish water systems and support channels for marine organisms to estuarine habitats for breeding/spawning</li> <li>• Water routes between inland waters and open sea</li> </ul>	<ul style="list-style-type: none"> <li>• Reclamation</li> <li>• Flooding and storm surge inundation</li> <li>• Delta water management</li> <li>• Water quality and quantity by disturbing natural by-passing channels of sediments</li> <li>• Over exploitation of natural resources (land, water, air, biological and socio-economics)</li> </ul>	<ul style="list-style-type: none"> <li>• Identify multiple uses by carrying out land use zoning based on hazard, risk and vulnerability studies on floods/cyclones</li> <li>• Ensure sufficient drainage and tidal flow</li> <li>• Plan channel dredging and tidal inlet stabilisation based on shoreline stability to preserve identified critical habitats</li> <li>• Biological indicators such as the extent of mangroves found upstream and presence of salt marshes may also be taken into consideration along with the salinity level of 5 PPT measured at the bottom of the estuary for determining the extent of tidal influence within the estuary</li> </ul>
<p>7.</p>	<p><u>Lowland Coast Spits and Barrier Islands</u></p> <ul style="list-style-type: none"> <li>• Developed in relatively low tidal range and low wave energy zones</li> <li>• Formed by the long-shore extension of spits that are broken through by storms into disconnected islands</li> <li>• Formed due to post-glacial sea level transgressions that swept sediments to the present-day coastline</li> </ul>	<ul style="list-style-type: none"> <li>• Sand mining</li> <li>• Tourism and unregulated economic/developmental activities</li> <li>• Erosion and sea level changes</li> </ul>	<ul style="list-style-type: none"> <li>• Discourage settlements and agriculture</li> <li>• Regulate tourism and developmental activities based on sustainable resource management plans to minimise vulnerability from cyclones/floods</li> </ul>

or breakwaters, steps may be taken by the agency involved to protect the shoreline at least up to 500 m on either side of the shoreline from erosion. In case of breakwaters for harbours, a stretch of at least 1 km on either side of the structure of the shoreline will be protected.

- iii) The agency responsible for the construction of the said structures will be entrusted with the monitoring of the shoreline for a minimum period of one year to
  - a) cover seasonal variations in the wave climate
  - b) address any issues of concern, if rivers, inlets or any water course is blocked by sandbar formation on its up drift side due to the construction of barriers jutting into the sea.

### 5.2.5 Infrastructure Development Scenario

5.2.5.1 The average coastal population density is 432 persons per sq. km as against 256 persons for the entire country. Apart from protecting the community and resources, there is a need for providing necessary infrastructural facilities for the communities to maintain a better standard of living and ensure their economic development. Development of infrastructure such as electricity, water, gas, roads, bridges, etc., are designed to serve multiple uses and is usually planned and provided by the government, but they may not be fully addressing the issues associated with protection of natural geomorphic barriers and sustainable natural resource management based on holistic CZM plans.

5.2.5.2 For lifeline economic infrastructure such as ports and harbours, the backup area on the land side (which incidentally falls within the coastal regulation zone) is crucial for supporting activities like port-based industries, processing units, container freight stations, container yards, storage

sheds, POL storage facilities, Special Economic Zones (SEZs), petrol pumps, service centres, recreational facilities, etc. Ports are meant to serve for a long period and have to consider all the development in subsequent years supported by engineering structures for protection, intake structures, inlets and entrance channels (breakwaters).

#### Zoning and Siting Plan of Infrastructure

- i) Regional plans depending upon the potential of development based on the CZM (covering assessment of coastal multi-hazard risk and vulnerability) will be evolved as per the town and country planning techno-legal framework of the concerned state/UT.
- ii) Regulation codes for construction and building activities will be implemented for the sustainability of coastal eco-systems.

5.2.5.3 The population of the coastal areas is likely to increase in the coming years with plans of establishing IT parks, Export Processing Zones (EPZs) and Special Economic Zones (SEZs). Settlements along the coast include large metropolitan areas, towns and rural settlements. Shoreline real estate is in great demand for human settlement and various agricultural, marine based activities, trade and industry, shipping, fishing and recreation. While expansion of the waterfront may be necessary for the coastal cities, it may jeopardise coastal resources. Expansion of townships and cities has put certain eco-systems such as mangroves, salt marshes, and mudflats, under pressure. The settlements of local communities have to be protected against natural calamities.

### 5.2.6 Coastal Aquaculture Scenario

5.2.6.1 The potential area available in the coastal regions of the country for aquaculture is 1.2 to 1.4

million ha. Presently, an area of about 1,57,000 ha is under shrimp farming with an average production of about 1,00,000 tonnes of shrimps per year. The Aquaculture Authority, Chennai, functioning under the administrative control of the Ministry of Agriculture, GoI, is responsible for ensuring that agricultural lands, salt pan lands, mangroves, wetlands, forest lands, land for village common purposes and the land meant for public purposes are not used (or) converted for the construction of shrimp farms. The aquaculture authority promotes sustainable development of coastal shrimp farming activities based on 'Precautionary Principle' and 'Polluter Pays Principle' as its primary function.

5.2.6.2 Sustainable shrimp farming entails issues ranging from farm level management to integration of shrimp farming into coastal area management, shrimp health management and policy and socio-economic and legal issues. Present-day production has to take note of not only the markets but also a host of technical issues as well as the concerns of the environment.

5.2.6.3 In many areas, shrimp farms have developed in close proximity (in clusters) along creeks and estuarine watercourses. As the sustained development of shrimp culture relies on good quality source water, over-development of shrimp farms—through either management intensification or increased farm area - along a creek can affect the estuarine water quality to levels unacceptable for shrimp farming. This brings to focus the need for investigation on carrying capacity, which will address not only the physical areas of shrimp farms, but also their density and geographical distribution along a watercourse. Sustainable utilisation of available areas and infrastructure can lead to the development of unexploited resources with the potential of generating a large number of jobs and enormous social and economic benefits to the coastal regions of the country.

- i) Keeping in view the vast extent of potential areas which will be made available for aquaculture in the country, Aquaculture Authority, MoEF and the states/UTs will take urgent steps to identify them in every district.
- ii) Saline and degraded lands not suitable for other purposes will be identified as potential areas for coastal aquaculture activities.
- iii) It is critical to ensure good quality of water source. However, groundwater will not be permitted to be drawn.
- iv) Such identified areas/zones will also find a place in the Integrated Coastal Zone Management (ICZM) plan of the coastal states/UTs to ensure optimal utilisation of scarce coastal land resources.
- v) In such areas, facilities, on the lines of software parks and industrial estates, will be provided to enable shrimp farming to be taken up in a scientific and environmentally sustainable manner with appropriate management practices, common waste water treatment plants, etc., by avoiding inter-sectoral conflicts.
- vi) Large tracts of agricultural land was converted for shrimp farming thus degrading them completely and rendering them unsustainable for agricultural activities. Immediate efforts will be made to enumerate them and evolve suitable regeneration strategies.

## 5.2.7 Coastal Regulation Zone (CRZ)

5.2.7.1 The first focused initiative towards the protection of coastal zones in India was taken up in 1981 by the then Prime Minister Smt. Indira Gandhi. She wrote to the Chief Ministers of all the coastal states, directing them to avoid all activities up to 500 metres from the maximum high tide line along the coast. In the wake of this direction, the

Department of Environment (DoE), which was a part of the Ministry of Agriculture, set up a Working Group on 'Environmental Guidelines for Development of Beaches'. The report of the Working Group, submitted in June 1983, was prepared after a scientific study was done taking into account the coastal and marine environment, natural hazards, socio-economic problems and developmental activities. These guidelines were prepared in consultation with the coastal states and UTs. The guidelines also suggested that construction along the coast, irrespective of their location, i.e., even beyond 500 m of the high tide mark, will be subjected to Environmental Impact Assessment (EIA) studies. The guidelines were circulated to all coastal states and UTs in March 1984. However, none of the states/UTs prepared the required Environmental Management Plans as per the guidelines.

5.2.7.2 The Ministry of Environment and Forests (MoEF) has the responsibility of framing legislation and implementing measures for protecting and conserving the environment of the country, including the marine environment up to the Exclusive Economic Zone (EEZ) (12 nautical miles). For the purpose of protecting and conserving the environment, the Environment (Protection) Act, 1986 (EPA) has been enacted as an 'umbrella legislation'. Under the EPA, MoEF has issued various notifications for the control of pollution and conservation of environmentally sensitive areas. In order to regulate multifarious activities going on in coastal zones which have resulted in over exploitation of marine and coastal resources and marked the degradation of the quality of coastal habitats and environments, the CRZ notification was issued in February 1991.

### 5.2.8 Implementation of CRZ Notification

5.2.8.1 The CRZ notification requires the states/UTs to prepare coastal zone regulatory management plans within a period of three months. While this was not complied with, MoEF started receiving

proposals from the coastal states/central ministries, industry associations, local communities and NGOs requesting for amendment to the CRZ notification on certain specific issues. After examining this proposal, MoEF constituted different committees to examine specific issues. Some of the committees constituted were:

- i) Fr. Saldahna Committee (Groundwater and sand mining issues in Lakshadweep and Andaman and Nicobar Islands)
- ii) B.B. Vohra Committee (Relaxation for tourism projects)
- iii) Balakrishnan Nair Committee (Issues relating to Kerala)
- iv) Fr. Saldahna Committee (East coast road and issues related to the East Coast)
- v) Sukthankar Committee (National policy for coastal zone management)

5.2.8.2 The Sukthankar Committee was the first to look into the National Coastal Zone Management Policy issues. The objectives of coastal zone management policy are to protect coastal communities, conserve coastal resources by ensuring functional integrity of the various coastal systems and maintain a balance between development and environmental protection.

5.2.8.3 Coastal areas were classified into four zones as given below:

- i) Ecologically and Geomorphologically Important Areas (EGIA)
- ii) Areas of Particular Concern (APC<sup>1</sup>)
- iii) High Hazard Zone (HHZ): a preservation zone which includes coastal seas, bays, gulfs, their beds, adjoining beaches, inland water bodies and land area up to 50 year setback line, except EGIS and APC
- iv) Low Hazard Zone (LHZ): conservation zone

5.2.8.4 Based on the recommendations of various committees/requests made by different agencies,



MoEF amended the CRZ Notification 12 times since August 1994 as per the provisions laid down in the Environment (Protection) Act, 1986. Despite major efforts by MoEF and the states, CRZ guidelines were not fully implemented and continue to be so even today. In the context of CRZ provisions, the following observations are made after the tsunami disaster of December 2004 along the Indian coast:

- i) The maximum damage had occurred in low-lying areas near the coast.
- ii) High casualties were found in thickly populated areas.
- iii) Mangroves, forests, sand dunes and coastal cliffs provided the best natural barriers against the tsunami.
- iv) Heavy damage was reported in areas where sand dunes were heavily mined (e.g., Nagapatinam and Kolachal) and where coastal vegetation was less.

5.2.8.5 The buffer provided in the coastal zone and our approaches for conservation of mangroves/sand dunes/coral reefs/coastal forests were all put to test during this event and were found to be reasonably effective even in calamities of this magnitude.

This leads us to the necessity for an effective mechanism to correct our approach and to incorporate coastal zone vulnerability indices in management practices.

#### 5.2.8.6 Swaminathan Committee Report

In order to make a CZM plan within the coastal regulatory framework for India that is fully consistent with well established scientific principles and also for comprehensively reviewing the CRZ Notification, 1991, the central government constituted an Expert Committee under the Chairmanship of Prof. M.S. Swaminathan on 19 July 2004. The Committee comprising experts from marine-ecology, geology, sociology, law, coastal engineering, marine pollution, biodiversity and remote sensing had submitted its

report on 14 February 2005. The MoEF has accepted the broad recommendations of the Report on 20 April 2005. The main recommendations are:

- i) Implementation of the ICZM Plan instead of an uniform regulatory approach.
- ii) Allow development along the coastal stretches based on the vulnerability/setback line.
- iii) Inclusion of the ocean zone in the CRZ.
- iv) Setting up of a National Institute for sustainable coastal zone management to address policy and legal issues.
- v) Address coastal water pollution in a time-bound manner.
- vi) Identify, map and protect the coastal eco-sensitive areas such as mangroves, corals, turtle breeding areas, etc.
- vii) Develop bio-shields along the coastal stretches.

5.2.8.7 In order to protect the coastal environment and the life and property of the people along the coastal areas from natural hazards, including tsunami, the Swaminathan Committee has further recommended that:

- i) Mangrove wetlands will be regenerated.
- ii) Coral reefs, grass beds and coastal forests will be preserved and conserved for both short-term and long-term ecological and livelihood benefits.
- iii) Coastal plantations like casuarinas, saliconia, palm, bamboo, etc., will be raised which will act as an effective bio-shield.
- iv) Geomorphologic features like sand dunes, beaches, coastal cliffs will be protected.
- v) Impact of natural hazards in the coastal and marine areas will be taken into account while formulating coastal area management schemes.



5.2.8.8 In order to implement the recommendations of the Swaminathan Committee, MoEF has initiated steps for demarcating the vulnerability line all along the coastal areas of the country. The vulnerability line is a setback line to be demarcated on the coastal stretches, taking into account the vulnerability of the coast to natural and man-made hazards. This will be based on seven scientific parameters: elevation, geology, geomorphology, sea level trends, horizontal shoreline displacement (erosion/accretion), tidal ranges and wave heights. A pilot study has been taken up jointly by the Sol, Centre for Earth Science Studies (CESS), SAC and Integrated Coastal Area and Marine Management (ICMAM) Directorate for the purpose of demarcating the Vulnerability Line along the coastal stretches of Gujarat, Karnataka, Tamil Nadu and West Bengal. Based on the Vulnerability Line demarcation, a draft Coastal Zone Management Legislation would be issued inviting public suggestions/objections and a decision would be taken as per EPA.

### 5.2.9 Issues for Priority Implementation

5.2.9.1 It is observed that the approach has been shifting constantly to the question of regulation and management of coastal zones. Though action has not been taken on this so far, it is to be noted that there are, however, other critical ongoing activities in the coastal areas such as dredging, break water construction, jetties etc., which have a direct impact over the inter tidal area, will also be examined as part of coastal zone management.

5.2.9.2 In the late 1990s, the Hon'ble Supreme Court of India passed orders upholding the CRZ notification and directing preparation of CZM plans. Such plans were prepared by most states, but action and violations have been continuing. Under these circumstances, a fresh notification under EPA is being contemplated on the basis of the Supreme Court Report recommendations on

ICZM which are very comprehensive. However, issues beyond the recommendations of the Swaminathan Committee Report involve sustainability of coastal resources. Such a comprehensive resource management plan at the local scale and fully incorporated with assimilative and supportive capacities of land, water, air, biological and socio-economic sectors of the coastal zones can ultimately reduce the overall vulnerability in the long term. Beyond the recommendations of the Swaminathan Committee Report, a holistic approach to the sustainability of coastal resources and environment based on the existing and future (climate change and sea level rise) local scale vulnerability profile has to become a part of ICZM.

5.2.9.3 It is of course, necessary to associate local communities with the management of coastal resources for safeguarding human and ecological security in coastal areas. Enhancing the economic well-being of the fishing and farming communities along the shoreline through an integrated bio-shield programme is of high priority. In the medium term, integrated and ecologically-socially sustainable CZM systems will be put in place jointly by government agencies and coastal communities.

## 5.3 Issues of Sustainability of Coastal Resources and Environment

5.3.1 ICZM is a continuous and dynamic process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal systems and resources. ICZM is a unitary programme which has to manage development and conserve natural resources and, while doing so, has to integrate the concerns of all relevant sectors of society and of the economy. Also, it is important that coastal economic development is essential for improving the human development index of the coastal

population. This will have to be done by ensuring biological diversity conservation and productivity of coastal eco-systems. There is need for continuous studies of ICZM plans for various sectors.

#### 5.3.1.1 Additional ICZM Issues in India for Various Sectors

ICZM is not new in India and in the past decade a number of CZM projects have been taken up. It is necessary to prepare ICZM plans based on the concept and premises of carrying capacity and ensuring community involvement at all stages of preparation of the plan. ICZM will therefore envisage optimum utilisation of coastal resources, minimisation of the impact of natural disasters and improvement in the equitable quality of life levels while ensuring protection of the environment and ecology. The key to success seems to be an inter-sectoral integrated approach using institutional development, village organisations and social mobilisation and land, shoreline and water resources management as a basic means. Together, they can achieve the goals and objectives of ICZM, which are:

- i) Reduction of the impact of natural disasters (storm surges, high winds and flooding).
- ii) Optimisation of the use of coastal resources (economic development and environmental protection).
- iii) Improvement of livelihood (poverty alleviation and achieving equity).

#### 5.3.2 Estimation of Assimilative Capacity and Delineation of Regional Environmental Management Plans

This includes various environmental and associated factors of coastal zones to be dealt holistically:

- i) Water Environment: Inventory of water resources (surface and ground) with respect to quantity and quality and seasonal variations, including delineation of

assimilative capacity based regional water environment management plan.

- ii) Land Environment: Delineation of a regional land environment management plan.
- iii) Biological Environment: Collection of information on flora and fauna in the region, including primary production, nutrients, salinity, sea grass and sea weed distribution and mangrove vegetation using in situ measurements, analysis of remotely sensed data, including delineation of regional biological environment management plans and including them in the conservation plans.
- iv) Air Environment: Issues of concern are prediction of the impacts on the air environment due to the proposed industrial developmental plans and alternate developmental options, and delineation of an assimilative capacity based air environment management plan.
- v) Noise Environment in Urban Areas: Delineation of an acoustic environment management plan in view of the aquatic fauna in the zone.
- vi) Socio-Economic Environment: Collection of baseline data on human settlements, demographic patterns, occupation, economic status, and health status of the community and also existing facilities for social welfare and health care, including delineation of socio-economic, historical and cultural status of the people.

#### 5.3.3 Estimation of Supportive Capacity

- i) Assessment of fisheries activity, its impacts and options for benefit enhancement.
- ii) Delineation of coastal erosion processes and extent of coastal flooding.
- iii) Assessment of competing demands for land for aquaculture, agriculture, mining, industry, forestry and settlements, and delineation of

best land use options for activities like SEZs, EPZs etc.

- iv) Assessment of available surface and groundwater resources in terms of quantity and quality and resource potential enhancement options vis-à-vis increasing needs.

#### 5.3.4 Evaluation of Alternative Developmental Scenarios and Delineation of a Preferred Scenario

- i) Evaluation of alternative scenarios through consequence analysis in terms of carrying capacity indicators including hazard/vulnerable reduction plans.
- ii) Delineation of preferred scenarios in terms of a prioritized developmental action plan, which includes technological interventions, policy reforms and institutional capacity building, including mechanisms for participating in resource management plans.

#### 5.3.5 Delineation of Institutional Mechanism and Capacity Development

- i) Review of existing environment and resource management programmes including environmental regulation, fisheries management, conservation, beach erosion management and pollution control.
- ii) Identification of training needs in the sectoral line agencies and organise the necessary efforts.

#### 5.3.6 Development of Resource Management Strategies

5.3.6.1 The basis for the Resource Management Plan (RMP) is the environmental capacity of the resources, mainly land and water. The essential information on potential opportunities and conflicts/constraints are required to be used in the formulation of the developmental action plan. A case study approach is to be adopted to maximise realistic

and useful results. A Consequence Analysis Tool has to be developed for generating output scenarios in terms of sustainable development indicators, such as per capita income, and assimilative capacity usage and also handle different scenario prescriptions for change in land use, population growth and other affected factors.

#### 5.3.7 Cyclone Disaster Prevention and Impact Minimisation Strategies

5.3.7.1 The development of GIS based Expert Decision Support System (EDSS) on ICZM covering river basins, deltas and other vulnerable areas along the coast will be useful for optimum utilisation of coastal resources, disaster prevention and impact minimisation plans through analysis of various scenarios. Sustainable coastal zone development can only be realised when integrated water and shoreline management is in place, when risk assessment becomes part of the planning process, when an equitable distribution of development is secured to alleviate poverty and reduce cyclone vulnerability, and when early warning is effective at the sub-district scale.

Till follow-up administrative actions on the Swaminathan Committee report are formalised through broad-based dialogue with all stakeholders, the following will be initiated under the existing CRZ regulations:

- i) Better implementation of existing CRZ regulations, especially in areas where eco-systems are degraded.
- ii) Specific micro-surveys will be undertaken to enable the listing of coastal bio-shields, species-specific nurseries and supporting physical infrastructure. Such an exercise using CARTOSAT data will be taken up by NRSA prior to and after the monsoon season every year.
- iii) EDSS for sectoral vulnerability assessment and sustainability of resources will be developed by coastal states/UTs.

## 5.4 Coastal Resources

5.4.1 Coastal environmental resources comprise of diverse set of natural and man-made assets, including mangroves, coral reefs, estuaries, coastal forests, genetic diversity, sand dunes, geomorphologies, sand beaches, land for agriculture and human settlements, coastal infrastructure and heritage sites. These provide habitats for marine species which, in turn, comprise the resource base for large numbers of fishermen, protection from extreme weather events, a resource base for sustainable tourism and agricultural and urban livelihoods. In recent years there has been significant degradation of coastal resources, for which the proximate causes include poorly planned human settlements, improper location of industries and infrastructure, pollution from industries and settlements, ship-breaking activities and over-exploitation of living natural resources. In future, rise in sea levels due to climate change may have major adverse impacts on the coastal environment.

Prioritized Actions include:

- i) Delta water management involving proper drainage and regulation of aquaculture even beyond the CRZ with a view to protect freshwater storage will be ensured.
- ii) Each state will promote ICZM Plans based on the above principles and initiate strong institutional statutory arrangements, where appropriate, to implement such plans.
- iii) Internationally, the impact of climate change at the eco-system level is monitored through the establishment of Flux Monitoring Networks (FLUXNET). At present, the Indian sub-continent is a major gap. It is an opportune time for India to set up such a network to study the impact of changing climate getting manifested in various ecological environments. This may be taken up jointly by DST, DoS, MoEF, CSIR and MoES during the Eleventh Five-Year Plan. FLUXNET essentially involves:

- a) Monitoring of coastal and marine eco-systems with the help of greenhouse flux gases measurement on a continuous basis involving S&T institutions and/or universities.
- b) Establishing of similar monitoring systems over the land eco-environment is absolutely essential for long-term planning of adaptation strategies pertaining to climate change manifestations (in respect of agriculture, forests, water quality and quantity, etc.) in the coastal zones.

5.4.2 A National Eco-system Research Advisory Committee under the chairmanship of the Secretary, MoEF, with representatives from the Coast Guard, MoES, Central Marine Fisheries Research Institute, Kochi and SAC as well as a few expert scientists from universities and institutions is constituted to assist the government on policies and action programmes for conservation of all eco-systems.

- i) State governments/UTs could consider constitution of a State Level Coastal Eco-system Advisory Committee with representatives of concerned departments and experts in the field to undertake conservation activities in a coordinated, scientific and sustainable manner.
- ii) MoEF supports research through identifying a broad approach towards sustainable development and integrated Management Action Plans (MAPs) with 100% assistance. Admissible components of funding assistance for MAPs are:
  - a) Survey, assessment and demarcation.
  - b) Capacity building, staff training and skills.
  - c) Shelterbelt development.
  - d) Protection and monitoring.
  - e) Restoration and regeneration measures.

- f) Alternate and supplementary livelihoods.
- g) Community participation.
- h) Mangrove afforestation/plantation (degraded areas and open mud flat coverage by plantation).
- i) Biodiversity conservation.
- j) Sustainable resource development.
- k) De-silting.
- l) Impact assessment through concurrent and terminal evaluation.

MoEF will make separate budgetary provision under MAPs for the coastal districts of the country as a part of their national Plan.

## 5.5 Bio-Shields

5.5.1 Nature has provided biological mechanisms for protecting coastal communities from the fury of cyclones, coastal storms, tidal waves and tsunamis. Mangrove forests constitute one such mechanism for safeguarding the ecological security of coastal areas and the livelihood security of fishing and farming communities living in the coastal zone. This ecological, economic and social value will further increase if a rise in sea level takes place because of anticipated global warming. In addition to mangroves that grow only in the estuarine environment, there are many other tree species which can constitute valuable components of coastal shelterbelts. All such species confer in the short-term local economic and ecological benefits and in the long-term global environmental benefits through carbon sequestration. Non-mangrove bio-shields along the coastal zone are popularly known as shelterbelts. Shelterbelts are strips of vegetation composed of trees and shrubs grown along the coasts to protect coastal areas from high velocity winds. The forest departments in India have mastered the technique of raising

shelterbelts since 1970, in which casuarinas was the main species. Along with casuarinas, other ecologically and economically important species can also be grown taking into account the biophysical condition and available breadth and width of the area selected for raising shelterbelts.

5.5.2 Preparation of a comprehensive State of the Forest Report (SFR), including a National Forest Vegetation Map (NFVM), once every two years is the prioritised activity of the Forest Survey of India (FSI). It also prepares thematic maps through the use of remote sensing data with minimum essential ground truth verification on a 10-year cycle. FSI, in its endeavour to continually update itself technically, has assessed, for the first time, the forest cover of the whole country by employing digital interpretation of satellite data at 1:50,000 scale. Even at this scale, with the adoption of a digital method of interpretation together with physical inventory, FSI has been able to delineate and record all the forest areas down to 1 ha extent in some cases. All perennial woody vegetation (including bamboos, palms, coconut, apple, mango, neem, peepal, etc.) has been treated as trees and all land with tree crops, such as agro-forestry plantations, fruit orchards, tea and coffee estates with trees, etc., have been included in forest cover estimations. Mangrove cover has been classified into dense and open mangrove areas. The areas of mangrove cover so assessed have been merged in the respective figures of dense and open forest cover. A special effort is made in SFR in respect of mangroves and other shelterbelts where information at national, state/UT and district levels is generated. As per SFR 2005, the forest cover in the country is 769,626 km<sup>2</sup> and constitutes 23.41% of its geographical area.

## 5.6 Mangroves

5.6.1 Mangrove vegetation is found along the tropical and subtropical coasts. Mangroves consist

of a number of species of trees and shrubs that are adapted to survival in the inter-tidal zone. They are land plants growing on sheltered shores, typically on tidal flats, deltas, estuaries, bays, creeks and barrier islands. The best locations are where abundant silt is brought by rivers or on the backshore of accreting sandy beaches. Their physiological adaptation to salinity stress and to waterlogged anaerobic mud is high. They require high solar radiation and have the ability to absorb fresh water from saline/brackish water.

5.6.2 Mangroves in India roughly account for about 5% of the world's mangrove vegetation and are spread over an area of about 4,445 km<sup>2</sup> along the coastal states/UTs as per SFR 2005. The Sundarbans in West Bengal alone accounts for about little less than half of the total area under mangroves in the country, followed by Gujarat and the Andaman and Nicobar Islands.

5.6.2.1 Compared to the assessment in 2003, a marginal decrease of 3% in mangrove cover has been found to be largely due to damage of the mangrove cover as a consequence of 2004 tsunami that hit the Andaman and Nicobar Islands.

### 5.6.3 Economic and Developmental Setbacks due to Lack of Institutionalised Best Practices of Land Use

5.6.3.1 Threats to Mangrove Eco-systems: While mangrove forests have a specific ecological role in the coastal eco-system and provide a life support system for large sections of the coastal poor, their destruction is widespread for shorter economic benefits. In recent times there has been increased ingress to convert them for aquaculture and agriculture. Use of chemicals/fertilizers and pollution in the upstream of aquaculture farms are detrimental to the mangrove eco-systems in the vicinity. Even in the case of captured fisheries, the production will be adversely affected. With the fishing grounds already over-exploited, mangrove destruction can only further reduce stock and production. In general, the mangroves are resistant to varied kinds of environmental perturbations and stresses. However, mangrove species are sensitive to excessive silting or sedimentation, stagnation, surface water impoundment and major oil spills. Seawalls, bunds and other coastal structures often restrict tidal flow, resulting in the killing of mangroves. It is important

**Table 5.2 Mangrove Cover in Coastal States/UTs (2005)**

S. No.	State/UT	Area in Km <sup>2</sup>				
		Very Dense Mangroves	Moderately Dense Mangroves	Open Mangroves	Total	Change in % with respect to 2001 Assessment
1	Andhra Pradesh	0	15	314	329	0
2	Goa	0	14	2	16	0
3	Gujarat	0	195	741	936	20
4	Karnataka	0	3	0	3	0
5	Kerala	0	3	5	8	0
6	Maharashtra	0	58	100	158	0
7	Orissa	0	156	47	203	0
8	Tamil Nadu	0	18	17	35	0
9	West Bengal	892	895	331	2118	-2
10	Andaman & Nicobar	255	272	110	637	-21
11	Daman & Diu	0	0	1	1	0
12	Puducherry	0	0	1	1	0
<b>Total Area</b>		<b>1,147</b>	<b>1,629</b>	<b>1,669</b>	<b>4,445</b>	<b>-3</b>

Source: State of Forest Report, 2005.



to recognise that many of the forces, which detrimentally alter mangroves, have their origins outside the mangrove eco-system.

5.6.3.2 Land Degradation and Biodiversity: Land degradation-which occurs through the natural and man-made processes of wind erosion, water quality and quantity and water-logging-has been identified as one of the priority concerns in India. Poor land use practices and management are responsible for the rapid land degradation in India. Loss of biodiversity is of great concern since many plant and animal species are severely threatened by destruction of their habitat and over-exploitation of resources.

#### 5.6.4 Options for Best Land Use Practices

5.6.4.1 Degradation of land through soil erosion, alkali-salinisation, water logging, pollution and reduction in organic matter content has several proximate and underlying causes. The proximate causes include loss of forest and tree cover (leading to erosion by surface water run-off and winds), unsustainable grazing, excessive use of irrigation (in many cases without proper drainage, leading to leaching of sodium and potassium salts) and improper use of agricultural chemicals (leading to accumulation of toxic chemicals in the soil), diversion of animal wastes for domestic fuel (leading to reduction in soil nitrogen and organic matter) and disposal of industrial and domestic wastes on productive land. In coastal areas, tree farming and conservation of mangroves result in more sustainable development.

The following specific initiatives will be taken:

- i) The policies and incentives for afforestation will be such that ecological and income security are both safeguarded.
- ii) Encourage adoption of science-based and traditional, sustainable land use practices and promote reclamation of wasteland and

degraded forestland covering both public and privately owned land giving necessary incentives, viz. right over the produce, provision of alternate land or compensation, etc.

- iii) Encourage agro-forestry, organic farming, environmentally sustainable cropping patterns and adoption of efficient irrigation techniques.
- iv) Shelterbelt regeneration and conservation of mangroves, most of which are on common property and will have to continue to receive budgetary support. Such support today is inadequate and will be enhanced in the interest of creating life and livelihood security in the coastal zones.
- v) An innovative funding mechanism will also be evolved by levying either a charge or a cess for all development activities in the coastal areas which would be pooled to reverse degradation and enhance conservation of green belts. It is also necessary to give some incentives to private landowners and fishermen to adopt sustainable practices.

#### 5.6.5 Threats of Existing Land Use Practices Affecting Mangrove Areas

5.6.5.1 Indian research communities have clearly delineated about 18 types of threats that mangrove areas are facing in different coastal states/UTs. These include grazing, tree felling, reclamation, urban development and geomorphic changes, pollution, silting, sedimentation and development activities, etc. The state-wise details of threats of existing land use practices affecting mangrove areas are already documented. Unless many of these threats are addressed through efficient management and regeneration programmes, the sustainability of mangrove habitats cannot be ensured.



### 5.6.6 Identification of Suitable Zones

5.6.6.1 Based on CRZ and best land use practices, it is necessary to plan for conservation and restoration of mangroves and raise tree shelterbelts extensively in all potential coastal zones. The CRZ Notification, 1991 under the EPA (1986) recognises the mangrove areas as ecologically sensitive and categorises them as CRZ-I areas, which implies that these areas are afforded protection of the highest order. Financial support is provided to coastal states/UTs in support of activities like survey and demarcation, remote sensing based monitoring, afforestation, restoration, alternative/supplementary livelihoods, protection measures, research, education and awareness. Based on information received from the states, groups of experts from MoEF, Botanical Survey of India (BSI), Zoological Survey of India (ZSI), state governments and experts from universities and research organisations would visit the sites to assess the suitability and feasibility of the proposed areas' inclusion under the National Mangrove Conservation Programme. Plantations are to be closely monitored so as to ensure their survival and growth involving state-of-the-art remote sensing technologies.

States/UTs will:

- i) Set up a Task Force to identify new mangrove areas on priority to enhance the spread of the mangrove areas in various states within six months.
- ii) Launch the dual mode mangrove plantation programme.
- iii) Take up direct planting of seeds or propagules in the muddy areas (plenty).
- iv) Take up planting of seedlings obtained from nurseries (seasonal effort and in small quantities). Nurseries are developed in upper parts of inter-tidal zones for 6-12 months and then transplanted to the field according to their zonation pattern.

- v) Select species will be made based on the availability and maturity of planting materials from the locality.
- vi) Restore primary consideration of the zonation pattern.
- vii) Make aggressive and sustained efforts to conserve the existing mangroves.
- viii) Initiate intensive mangrove plantation programmes at identified potential sites so as to develop bio-shields.
- ix) Officially classify mangroves as forests, and mangroves found anywhere will be placed under the control of the state forest departments. Important mangrove areas will be declared as protected areas if they are not already done.
- x) Make concerted efforts to undertake plantation of mangroves wherever possible along creeks, estuaries, deltas and shores, and of appropriate species of trees as windbreakers along the coastline and the dunes that back them.

### 5.7 Shelterbelt Plantations

5.7.1 Raising coastal shelterbelts to mitigate the adverse impact of cyclone winds is one of the short-term objectives of the National Afforestation Programme (NAP) scheme. However, this has not been taken up effectively. Further, the regeneration of degraded forests and adjoining areas in the coastal zones is not covered under NAP as per the plantation design and guidelines.

- i) MoEF will insist on raising coastal shelterbelts as a mandatory component of the NAP plans.
- ii) NAP guidelines will be expanded to include regeneration of degraded forests and adjoining areas to provide additional protection from cyclonic winds.

- iii) All coastal states/UTs will ensure that their NAP plans incorporate both the components so as to strengthen coastal bio-shields for facilitating their implementation.

### 5.7.2 Identification of Suitable Zones

5.7.2.1 Raising of shelterbelts all along the coastline needs a sound strategy. The shore areas are the most difficult areas having peculiar geological formations. In the interface zone where the land meets the sea, there are river mouths, salt pans, sand mounds, estuary mouths, creeks, backwaters, mangroves and habitations. In these interior shore areas, the land is under intensive cultivation of a variety of commercial crops. The villages are also densely populated. Therefore, raising of shelterbelts to fight cyclonic winds requires an appropriate strategy which is free from such problems and has practical applicability. Under the Shelterbelt Plantation Programmes along the coast, a width of 5 km from the shores has been considered since 1977. This 5 km width has been differentiated into the first 500 m zone or main zone and 500-5000 m zone as the support zone.

5.7.2.2 The Main Zone consists of afforestation with block plantations. The natural conditions prevailing in the main zone are very hostile and are characterised by salinity, poor soils with high pH, low nutrition, poor moisture retention capacity, inadequate irrigation facilities, subjection to high speed and salt laden winds, etc. For effective management of all these difficult areas, the entire main zone of 500 m along the coast has to be stock mapped. Stock maps are to be prepared indicating all types of areas, soils, crops, plantations, etc. After completion of preparation of the stock map, the method of treatment to be adopted on a particular piece of land may be decided.

5.7.2.3 A Support zone is aimed at saturating the area with tree crops planting around households,

public offices and all along the road margins and field bunds without leaving any gaps, including the difficult areas, with suitable species in the area between 500-5000 m. Islands offer unique ecosystems and coastal planning and regulation in their case will take into account features such as their geological nature, settlement patterns, volcanic or coral nature of the island, size of habitations, unique cultures, livelihood patterns, etc., along with adequate environmental safeguards.

### 5.7.3 Selection of Species and Efforts for Community Involvement

5.7.3.1 The selection of species has to be done by taking into consideration factors such as biodiversity, tidal amplitude, soil adaptability, enrichment of species diversity and maturity characteristics. The shelterbelt plantation programme has to be taken up on a regular basis and specifically after the passage of a cyclone. Tidal amplitude is an important factor to be considered for species selection and is an easily measurable method as the distance between the highest high-tide to the lowest low-tide water marks of a locality. Hence, species that prefer high-tidal amplitudes; mid-tidal amplitudes and low-tidal amplitudes are to be planted at their respective identified zones. Other general species can be planted at the back. All the shelterbelt plantation programmes in the main and support zones up to 5000 m from the coastline are to be implemented efficiently through the Joint Forest Management (JFM) concept and afforestation through the Vana Samrakshana Samithies (VSS) along with accrued monetary benefits. Community involvement and beneficiary oriented nursery programmes are crucial for the regeneration of forest cover and coastal shelterbelt consolidation and will be encouraged.

### 5.7.4 Monitoring Shelterbelt Plantation Zones

5.7.4.1 Management plans for coastal and shelterbelt plantations will be prepared by the

mapping of habitat utilisation patterns, including sea turtle and sea bird nesting beaches. Monitoring coastal shelterbelt plantations will be taken up on a regular and continuous basis. The use of remote sensing and other management options will be appropriately employed. Protection of shelterbelt plantation can be hampered by inappropriate eco-tourism activities and consumption of forest reserves.

Other important desired actions include:

- i) MoEF and state government departments will jointly commission a state-wise survey of conserved areas which would be appropriately designated as community reserves. The respective state governments will notify them and prepare management plans.
- ii) Local communities living in and around forest areas will be trained in eco-tourism activities, which will not only help ensure their livelihood security but could facilitate their involvement in forest conservation.
- iii) Annual mapping of shelterbelt plantation zones covering up to 5 km of coastline by utilising high resolution remote sensing satellite images from CARTOSAT type satellites will be undertaken to monitor coastal shelterbelt plantations.
- iv) Training will be imparted to forest officers, including IFS, in coastal and marine biodiversity conservation and management.
- v) Training will be imparted to police/Coast Guards for the enforcement of the Wild Life (Protection) Act, 1972.

### 5.7.5 Funding Support for the Spread of Mangroves and Shelterbelts

5.7.5.1 In order to develop a broad framework of mainstreaming Disaster Mitigation and Risk

Reduction with developmental planning, special allocations are to be made by MoEF. NAP has been started as a 100% Central Sector Scheme during the Tenth Five-Year Plan. NAP is implemented by involving a two-tier set-up, namely the Forest Development Agency at the Forest Division level and the Joint Forest Management (JFM) Committee at the village level. On an average, about Rs 250 crore were allocated for NAP during the Tenth Plan period covering all states of the country but without any special emphasis on coastal bio-shields.

Priorities of NAP:

- i) All 13 coastal states/UTs will complete the spread, preservation and restoration/regeneration of bio-shields during the Eleventh Plan Period. They will develop suitable plans for enhancement of specific budgetary support to achieve this.
- ii) Similarly, the regeneration of degraded forest and adjoining areas in the coastal zones will also be covered under NAP.

## 5.8 Coastal Flood Plain Management

### 5.8.1 Flood Plain Zoning and Management

5.8.1.1 Flood plain zoning aims at disseminating information on a wider basis so as to regulate indiscriminate and unplanned development in flood plains and is relevant both for unprotected as well as protected areas. Flood plain zoning is not only necessary in the case of floods by rivers but is also useful in reducing the damage caused by drainage congestion, particularly in urban areas where on grounds of economy and other considerations urban drainage is not designed for the worst conditions and undervalues damage during intense storms whose magnitude exceeds that for which the drainage system is designed. The CWC has been continuously impressing upon the states for

necessary follow up action to implement the flood plain zoning approach. Even though, a model draft bill was circulated by the Union Government for flood plain zoning legislation in 1975 to all the states for enactment, the states seem to have reservations. This draft flood plain zoning bill covers all river basins in the country. The basic requirements for implementing flood zoning are as follows:

- i) Broad demarcation of areas vulnerable to floods and coastal inundation associated with cyclones will be done.
- ii) Preparation of detailed digital contour mapping of such areas to a large scale (preferably 1:15,000/1:10,000) with contours at intervals of 0.25 m or 0.5 m.
- iii) Fixation of reference river gauges with respect to which the areas likely to be inundated for different magnitudes of floods, will be determined.
- iv) Mapping of areas prone to flooding with return period of 2, 5, 10, 20, 50 and 100 years. Similarly, areas likely to be affected on account of accumulation of rainwater for different frequencies of rainfall like 5, 10, 25 and 50 years, are to be mapped.

Priority Actions are:

- i) CWC will take up formulation of a regulatory framework for flood plain zoning in coastal areas and flood inundation management associated with cyclones.
- ii) State governments will constitute the task teams jointly with CWC, comprising officials and experts, to address the issue of land use regulation in different flood zones and develop specific guidelines for flood zoning based on scientific studies.

## 5.9 Groundwater Resources

5.9.1 The quality of groundwater in coastal areas by and large is fresh, except in certain areas where it is found to be saline/brackish either due to salinity ingress or inherent salinity in the geological formations constituting the aquifer systems. Despite large quantum of freshwater discharge in the coastal areas of West Bengal comprised of the Bengal Delta formed by the Hoogly-Bhagirathi river systems and underlain by unconsolidated fluvial sediments, the groundwater is saline down to a depth of 110-150 m within 20-30 km inland from the coast with an alarming pace of freshwater depletion.

**Table 5.3 Groundwater Potential in Coastal States as on March 2004**

State/Union Territory	Resources (billion cubic metre/yr)	Development (%)
Andhra Pradesh	36.5	45
Goa	0.28	27
Gujarat	15.81	76
Karnataka	15.93	73
Kerala	6.84	47
Maharashtra	32.96	48
Orissa	23.09	18
Tamil Nadu	23.07	85
West Bengal	30.36	42
Dadra & NH	0.063	14
Daman & Diu	0.009	107
Lakshadweep	0.012	63
Puducherry	0.029	105
<b>Total</b>	<b>184.953</b>	<b>57.46 (Average)</b>

5.9.2 The major problems in the groundwater sector of coastal areas are over-development leading to an ever-increasing freshwater demand, declining water table leading to reduction in sustainability of tube wells and salinity ingress in coastal aquifers.

Priority Actions are:

- i) Groundwater development will be regulated in coastal areas to avoid salt water intrusion. Groundwater recharge schemes will be taken up on priority to avoid permanent damage of the aquifers.
- ii) Urban corporations/municipalities will set up desalination plants to meet their ever increasing freshwater requirements as MoES has successfully implemented the low cost technology in Chennai, Lakshadweep and in some industrial sectors of Tamil Nadu.
- iii) The roof water and other rainwater harvesting techniques practiced in Lakshadweep Kerala, Tamil Nadu, etc., will be replicated in the entire coastal belt for the sustainability of the groundwater, which will be used only in emergencies.

## 5.10 Coastal Erosion

5.10.1 The Indian coastline extends to a length of about 7,516 km. Almost all the maritime states/UTs are facing the problem of coastal erosion in varying degrees. About 1450 km of coastline has been reported to be affected by sea erosion, of which about 700 km has been protected and 750 km is yet to be protected.

5.10.2 Coastal erosion in India has resulted in the loss of valuable beaches and adjacent coastal land used for habitation, agriculture, recreation, etc. Erosion also leads to damage of coastal highways, industries and other coastal installations. Protection of coastal areas requires careful planning,

management and execution of appropriate schemes. Protection works will be based on long-term vision and planned to suit the specific site conditions after thorough field investigation and development of an adequate database. There is a need to take up a judicious combination of structural and non-structural measures that do not disturb the ecology of the area and are cost-effective.

Steps for planning of effective coastline protection are:

- i) The changes in shoreline/coastal erosion can be monitored manually and through satellite imageries. Shoreline changes will be studied regularly by using CARTOSAT data and involving DoS or other state/central agencies engaged in remote sensing.
- ii) Information regarding various factors such as wave height and period, water levels, currents at a number of points in the sea, beach cross-section, type of beach material, silt discharge, etc., will be collected on a continuous basis for the planning and design of shore protection works.
- iii) The causes of erosion will be properly identified so that the most effective remedial measures are adopted. The causes of coastal erosion can be accounted largely by collecting necessary data about waves/tides, sea level changes and by monitoring monsoon vagaries and human interference.
- iv) The impact of coastal protection works on the existing conditions will be studied prior to their planning and implementation. Similarly, infrastructure development will also be subjected to EIA. Care will be taken to preserve and protect ecological, aesthetic, historic and archaeological resources.
- v) The impact of coastal protection works on the natural sediment transport system will

also be taken into consideration as negative, down drift impact on the local and regional sediment budget can be a key environmental constraint.

- vi) Any remedial measures will be taken up after proper investigation and scientific studies to assess their techno-economic viability and suitability of site. It will be ensured that protection measures do not shift erosion problem from one site to another.

### 5.10.3 Initiatives of the Government of India involving various States

#### 5.10.3.1 Coastal Protection and Development Advisory Committee

Realising the need of overall planning and a cost effective solution to the coastal problems, Gol constituted the Beach Erosion Board in 1966 to guide and implement the programme of anti-sea erosion work in Kerala. The government reconstituted the Board in 1971 and again in 1989, extending its jurisdiction to the entire coastline of the country. The Coastal Protection and Development Advisory Committee (CPDAC) provides a common platform to all maritime states/UTs to discuss and solve their coastal erosion problems.

#### 5.10.3.2 National Coastal Protection Project

Considering the problems faced by the states/UTs in taking up anti-sea erosion work due to paucity of funds, CPDAC requested the maritime states to formulate proposals for the protection of vulnerable coastal reaches from sea erosion in their respective states and send the proposals to CWC, which will coordinate and prepare a consolidated National Coastal Protection Project (NCP). On incorporating the requirements of the coastal states/UTs, NCP is under formulation for protection of coastal areas from sea erosion with a view to exploring the possibilities of funding through external/domestic resources.

#### 5.10.3.3 Centrally Sponsored Scheme for States

For protection of critical areas of maritime states/UTs from sea erosion, a centrally sponsored scheme, 'Critical anti-erosion works in coastal and other than Ganga basin States', estimated to cost Rs 20.64 crore was approved by the Ministry of Water Resources in March 2004 for implementation during the Tenth Five-Year Plan, which was subsequently revised to Rs 46.17 crores. The proposals of Karnataka, Kerala, Maharashtra, Orissa, Puducherry and Tamil Nadu are included in the pilot project on beach nourishment and preparation of a Coastal Atlas. The scheme has now been made a centrally sponsored scheme. Out of an estimated cost of Rs 46.17 crore, the Centre's share is Rs 38.57 crore and the states' share is Rs 7.60 crore. The central assistance is in the form of grants-in-aid to states restricted to 75% of the total cost of the scheme.

#### 5.10.3.4 Plans for Coastal Protection Works and Coastal Atlas

In order to facilitate the construction of coastal protection measures and have uniform guidelines for the formulation and approval of coastal protection schemes, a manual for execution of coastal protection works is under preparation by the National Institute of Oceanography, Goa, under the guidance of CPDAC. The coastal atlas would be prepared by SAC, DoS, Ahmedabad, by digitizing existing land use/land cover/shoreline changes. The land use map will mainly include agricultural land, forest, wetland, built-up land, barren land, reclaimed area, seawall/embankment, high waterline, low waterline, district/state boundary, CRZ boundary, etc. The status of coastal erosion in India, length of shoreline under various classes like eroding, stable, accreting, etc., will also be shown in the maps. The atlas will be beneficial to central and state government departments as well as other agencies involved in the planning and management of coastlines and implementation of coastal protection projects. The



digital database will be a permanent asset, which can be easily updated and utilised for various coastal zone management applications.

MoEF and MoES are the two ministries dealing with coastal and ocean areas. Besides, several other central and state government ministries, departments and agencies are involved in CZM in India. Coordination among these multiple stakeholders with MoEF as the primary focal point, will be strengthened.

## 5.11 New Environment Policy

### 5.11.1 The National Environment Policy (NEP), 2006

The National Environment Policy (NEP), 2006 is intended to be a guide to action in regulatory reforms, programmes and projects for environmental conservation, and review and enactment of legislation by agencies of the central, state, and local governments. NEP, 2006 lays great emphasis on the conservation and management of mangroves in the country as they are the symbiotic links between land and sea, and play a critical role in nurturing coastal and marine biodiversity besides mitigating cyclone hazard.

### 5.11.2 CZM issues related to NEP, 2006

Development activities in the coastal areas are regulated by CRZ notifications and ICZM plans made under them. However, there is need to ensure that the regulations are firmly founded on scientific principles, including the physical, natural and social sciences so as to ensure effective protection to valuable coastal environmental resources without unnecessarily impeding livelihoods or legitimate coastal economic activity or infrastructure development. Islands offer unique eco-systems and coastal planning and regulation in their case will take into account of all geomorphic features. It is recognised that states will require both technical

and financial resources for the preparation of ICZM plans.

### 5.11.3 Wetlands Conservation

5.11.3.1 Wetlands are under threat from drainage and conversion for agriculture and human settlements, besides pollution. This happens because public authorities or individuals having jurisdiction over wetlands derive little revenues from them, while the alternative use may result in windfall financial gains to them. On the other hand, reduction in the economic value of their environmental services due to pollution, as well as the health costs of the pollution itself, are not taken into account while using them as a waste dump. A holistic view of wetlands is necessary, which will look at each identified wetland in terms of its causal linkages with other natural entities and human needs, and its own attributes.

## 5.12 Crop and Livestock Protection

5.12.1 Recurring frequency of cyclones leads to drastic transformation in the pattern of coastal land use by turning fertile areas into saline wastelands due to marine incursions. In addition, standing crops are destroyed; salt deposits from saline water render farms unproductive and even barren. An entire cropping season is lost and areas affected by severe storm surge are sometimes not cultivable during subsequent seasons also. Very often harvested food crop stocks are also destroyed. Horticultural crops suffer heavy losses. Livestock including farm and dairy cattle, poultry, sheep and goats are also suffered.

### 5.12.2 Strategies for Protecting Standing Crops

5.12.2.1 The sector that is most affected by extreme weather/climate events is agriculture and food security. The sharpest falls in agricultural production has been experienced during those years that have



experienced the occurrence of severe TCs in India. Loss of agricultural production of rice, coconut, cereals (corn), sugarcane, banana, etc., is reflected in terms of gross state domestic product (GSDP) of coastal states/UTs. In addition, storm surge ingress inland curtails the prospects of agricultural yields for at least 1-2 subsequent cropping seasons. Various options that have been conceptualised for protecting standing crops are listed below:

- i) The crop calendar for major crops will be adjusted to normal cyclone periods. The cultivation of hybrid varieties of rice in the coastal areas, which can withstand surge waters, floods and cyclone winds without damaging the seed, its colour and straw, will be encouraged. Short duration and short height crops will be recommended. New irrigation schemes will have to be executed in the uplands keeping in view the putting of dry land into irrigation to compensate food and fodder.
- ii) Standing crops will be protected through improvement of drainage systems by executing the following activities:
  - a) Strengthening of bunds all along canals and tanks.
  - b) De-silting of tanks, canals and drains.
  - c) Widening and deepening of drains and canals.
  - d) De-weeding of tanks and canals from water hyacinth and other plants which obstruct normal flow.
  - e) Removal of encroachments from canals and tanks.
  - f) Diversion of drains and canals.
  - g) Alignment of new canals and drains keeping in view that water will be flowing out freely during disaster periods.
  - h) Drains which are directly joining the sea will be maintained regularly.
- i) Alternative storage facilities and processing units (boiler and dry pans) will be established.
- j) Tidal banks (with flap gates) will be constructed along irrigated lands where these are near the coast.
- k) Close main canals during cyclone periods, giving preference to drainage to adjacent fields/sectors.
- l) Ensure emergency input supply with emphasis on fertilizer and insecticide,
- m) Promote community threshing yards and drier facilities.
- n) Implement crop insurance.
- o) Proper application of sufficient fertilizers after inundation of storm surge to reduce salinity.

#### 5.12.3 Strategy for Protecting Cultivable Land from Salinity including Aquaculture Activities

- i) Restrictions will be imposed on change of agriculture to aquaculture, and aquaculture will be confined to zones of coastal areas where brackish water is available.
- ii) Pumping of brackish water into fresh water areas for aquaculture will not be allowed as it contributes directly to salinisation of surrounding lands and surface water.
- iii) Pumping of ground water for fresh water aquaculture will be restricted as it leads to depletion of fresh water resources and intrusion of saline water into groundwater reserves.

#### 5.12.4 Strategy for Protecting Livestock

- i) Shift the animals to a safer place as soon as warnings for impending cyclones are received.

- ii) Cowsheds to house the animals will be constructed in a way that they can withstand strong cyclone winds.
- iii) Animal sheds will be constructed with lightweight timber, coconut and palm tree leaves that will not harm the animals even if they collapse during cyclonic winds
- iv) Sufficient nutritious food will be preserved which can last for 10-15 days, and dry grass compressed to bales or blocks with machines under high pressure, can be stored in small areas.
- v) Animals will be vaccinated against communicable diseases during emergency periods and the carcasses of animals will be buried in a pit over which lime will be sprinkled. Sensitisation of cattle mounds near cyclone shelters will be undertaken.
- vi) Provide clean and unpolluted water to the animals and the water may be treated with chlorine or bleaching powder before giving it to the animals.
- vii) Increase the overall fodder resource through raising and preserving to meet the requirements during the crisis period. By-products of agriculture/industrial outputs are to be used as fodder. Encourage the growing of hybrid variety of nappier grass.
- viii) Some non-conventional resources are to be developed for use as fodder for animals.
- ix) Molasses is to be used as an alternate fodder during cyclone periods and periods of non-availability of fodder to protect the animals from disaster impacts and also from scarcity of food/fodder.
- x) To avoid deficiency in proteins and minerals, animals will be fed urea-molasses and multi-vitamin food.
- xi) The manure of other animals and poultry can be used to some extent as food. In the case

of poultry manure, nitrogenous material that can meet the protein requirements of animals will be made available.

### 5.12.5 Strategy for Protecting Poultry Industry

- i) Shift the birds to a higher and safer place as soon as warning for a cyclone is received.
- ii) Replace the moisture-infected feed with dry feed.
- iii) Birds which die due to diseases will be treated separately. The dead birds will be cremated or buried in a deep pit and lime sprinkled over it.
- iv) Keep the surroundings clean by sprinkling with lime or insecticides.
- v) Protect the birds from diseases by getting them vaccinated before hand. Keep the water meant for poultry clean by mixing anti-bacterial material.

5.12.6 Absolute security against cyclone hazard cannot be achieved, but an effective cyclone warning response coupled with the above mentioned short-term and long-term management options can definitely reduce loss of life and damage to property.

### 5.13 Livelihood Protection of Handloom Weavers

5.13.1 Handloom Weavers along the coast is another community which is adversely affected by cyclone and its associated hazards. For this group of community, after the cyclones or heavy rains, the damage sets in gradually which doesn't attract proper attention of authorities or even ignored. This differential impact needs cognizance for any cyclone prevention and disaster mitigation plans. Vulnerability of handloom weavers is evidently increasing due to heavy rains leading to reduction of their incomes and livelihood.

5.13.2 Most often handlooms in coastal areas are in pits. These pits get water either from surface (if it is a low lying area) or oozes from the ground. Handloom being made of wood, old enough, wood also gets weakened. In some places, there has been a collapse of pit and burial of loom along with it. A substantial part of handloom workers is an open sky operation. Pre-loom processing of yarn activities in handloom production are done in the open, in streets, in the shadows of houses, under thatched awnings or trees. Therefore, prolonged rain or adverse weather such as heavy rainfall generally associated with cyclone adversely affects livelihood of weaver community.

5.13.3 Construction of community weaving facility in high grounds in the village or close to the locality, in low lying coastal areas needs to be considered.

5.13.4 The special difficulties of the handloom weaver communities will become a part of all DM Plans at all levels.

A regular mechanism of providing due assistance to weaver community of coastal states/UTs need to be established by the Ministry of Textiles. State governments of coastal states will consider construction of some cyclone shelters in weaver community dominated villages situated in coastal low lying areas, with their ground floor to serve as community weaving facility.

## 5.14 Major Action Points

1. Mapping (at least at 1:25,000 scale) and delineation of coastal wetlands, patches (<20 ha, preferably) of mangroves and shelterbelts and identification of new areas for expansion of coastal bio-shields will be carried out on priority using high resolution satellite data (IRS LISS IV or CARTOSAT). Remote sensing-based annual monitoring mechanisms for containing degradation of coastal bio-shields and preservation of natural coastal barriers will be institutionalised (refer section 5.2.3).  
[Action: DoS; MoEF]
2. National wetland biodiversity registers, along with the economic evaluation of wetlands for a national resource accounting system, will be introduced. Wetland productivity studies will be commissioned by involving relevant organisations (refer section 5.2.3).  
[Action: MoEF; DoS; DBT]
3. Suitable coastal zones for shrimp aquaculture based on remote sensing tools will be identified. Setting up of shrimp farms will be regulated based on the carrying capacity of open water by incorporating remedial measures for ensuring the water quality. Potential coastal areas for shrimp aquaculture in the country will be re-assessed through remote sensing in order to avoid inter-sectoral conflicts with other legitimate users of the coastal resources. Shrimp farming will be regulated, only to be taken up in inherently saline and degraded lands which are otherwise unsuitable for any other productive purposes. Drawing of groundwater will not be permitted for shrimp farming (refer section 5.2.6).  
[Action: MoEF; environment departments/pollution control boards; etc.]
4. Responsibility for taking appropriate steps to ensure protection of the shoreline from erosion will be entrusted to the agency responsible for construction of a structure along with monitoring shoreline changes for a period of at least one year with regard to the preservation of natural barriers (refer sections 5.2.4, 5.2.6, 5.2.7).  
[Action: CWC; MoEF; shipyards; coastal areas development authorities; etc.]

5. Delta water management and freshwater storage/management options will be encouraged in coastal zones for optimal utilisation of water resources. Aquaculture will be regulated even beyond the CRZ with a view to protecting fresh water (refer sections 5.2.6, 5.3.1, 5.4).  
**[Action: State irrigation departments; coast development authorities]**
6. Suitable coastal zones, along with silting plan for locating various infrastructure development projects based on the provisions of the CRZ guidelines and technological framework of town and country planning departments in coastal states/UTs, will be identified. Implementation of the coastal regulation code for construction and building activities for sustainability of coastal eco-systems will be ensured (refer sections 5.2.7, 5.2.8).  
**[Action: MoEF; DoS; state forest departments; urban development and rural development departments of the states]**
7. Economic well-being of the fishermen and farming communities along the shoreline will be enhanced through an integrated bio-shield programme. ICZM plan development will address the optimum utilisation of coastal resources like land and water, economic development, protection of environment, reduction of cyclone disaster impacts (storm surges, high winds and rainfall induced flooding) and evolve impact minimisation strategies. States will be supported by concerned ministries of the Central government to build state-level technical capacities for implementation of ICZM plans (refer section 5.3).  
**[Action: State governments; MoEF; MoES; MoWR]**
8. An exclusive eco-system monitoring network will be set up to the study impacts of changing climate (refer section 5.4.1).  
**[Action: MoEF; MoES; DST; DoS; MoWR; CSIR]**
9. State governments/UTs could consider the constitution of State Level Coastal Eco-system Advisory Committees with representatives of the concerned departments and experts in the field to undertake conservation activities in a coordinated, scientific and sustainable manner. Separate budgetary provision under MAPs for coastal districts of the country will be provided as part of the cyclone impact mitigation efforts (refer section 5.4.2).  
**[Action: SDMAs/DDMAs; MoEF]**
10. Implementation of the following initiatives for the best land use practices will be institutionalised:
  - i) Policies and incentives for afforestation to safeguard ecological and income security.
  - ii) Adoption of science-based and traditional, sustainable land use practices.
  - iii) Giving necessary incentives for reclamation of wasteland and degraded forest land covering both public and privately owned lands by conferring rights over the produce, provision of alternate land or compensation, etc.
  - iv) Encourage agro-forestry, organic farming, environmentally sustainable cropping patterns, and adopt efficient irrigation techniques (refer section 5.6.4).  
**[Action: Coastal states/UTs; MoEF; MoRD; MoWR]**

11. Enhanced budgetary support will be provided for shelterbelt plantation and conservation of mangroves in the interest of livelihood security in the coastal zones. Innovative funding mechanisms will also be evolved by levying either a charge or a cess for all development activities which would be pooled to reverse degradation and enhance conservation of green belts. Some incentives will be offered to private land owners and fishermen to adopt sustainable practices (refer sections 5.6.4, 5.7.5).

[Action: Coastal states/UTs; MoEF; MoRD]

12. The following initiatives for sustenance of mangrove belts will be institutionalised:

- i. Setting up of a Task Force in consultation with states to identify new mangrove areas on priority to enhance the extension of mangrove areas in various states within six months.
- ii. Launching a dual mode mangrove plantation programme:
  - a) Extensive direct planting of seeds or propagules in the muddy areas.
  - b) Seasonal transplanting of seedlings obtained from nurseries, developed in the upper parts of inter-tidal zones for 6–12 months.
- iii. Efforts for sustained conservation of the existing mangroves.
- iv. Intensive mangrove plantation programmes at identified sites.
- v. Officially classify mangroves found anywhere as forests and place them under the control of State Forest Departments as protected areas.
- vi. Undertake plantation of mangroves, wherever possible, along creeks, estuaries, deltas and shores, using

appropriate species (refer sections 5.6.6).

[Action: Coastal states/UTs; MoEF]

13. All coastal states and UTs will complete the spread, preservation and restoration/regeneration of bio-shields during the Eleventh Plan period (refer section 5.7).

[Action: MoEF; states/UTs]

14. Raising of coastal shelterbelts will become a mandatory component under NAP and guidelines of NAP will be expanded to include regeneration of degraded forests in adjoining areas to provide additional protection from cyclone winds. All coastal states/UTs will formulate NAPs accordingly and implement activities from 2008–09 (refer section 5.7.1).

[Action: MoEF; coastal states/UTs]

15. CRZ regulations will be implemented efficiently in areas where eco-systems have been degraded. Annual listing of coastal bio-shields, species specific nurseries and supporting physical infrastructure will be undertaken using CARTOSAT data during the pre-monsoon and post-monsoon seasons (refer section 5.7.4).

[Action: DoS; MoEF; state governments/UTs]

16. Following are some other important actions:

- i) MoEF and state government departments will jointly commission a state-wise survey of conserved areas which would be appropriately designated as community reserves. Respective state governments will notify them and prepare management plans.
- ii) Local communities living in and around forest areas will be trained in eco-tourism activities, which will not only

help ensure their livelihood security but could also facilitate their involvement in forest conservation.

- iii) Annual mapping of shelterbelt plantation zones covering up to 5 km of coastline by utilising high resolution remote sensing satellite images from CARTOSAT type satellites will be undertaken to monitor coastal shelterbelt plantations.
- iv) Training will be imparted to forest officers, including IFS, in coastal and marine biodiversity conservation and management.
- v) Training will be imparted to police/Coast Guards for enforcement of the Wild Life (Protection) Act, 1972 (refer section 5.7.4).

[Action: MoEF; state governments/UTs; SDMAs/DDMAs]

17. A regulatory framework for flood plain zoning and flood inundation management in coastal areas associated with cyclones, will be formulated in six months. State governments will constitute task teams jointly with CWC, comprising officials and experts, to address the issue of land use regulation in different flood zones and develop specific guidelines for flood zoning based on scientific studies. (refer section 5.8).

[Action: CWC, state irrigation departments]

18. Groundwater development will be regulated strictly in addition to the launch of appropriate groundwater recharge schemes. ULBs/PRIs will set up desalination plants to meet their ever increasing freshwater requirements (refer section 5.9).

[Action: Central Groundwater Board (CGWB); state Groundwater Boards

(GWBs); MoES; Panchayati Raj and Rural Development ministries]

19. The following initiatives will be taken for effective coastline protection:

- i) The changes in shoreline/coastal erosion will be monitored manually and through satellite imageries. The shoreline changes will be studied regularly by using CARTOSAT data and involving DoS or other state/central agencies engaged in remote sensing.
- ii) Information regarding various factors such as wave height and period, water levels, currents at a number of points in the sea, beach cross-section, type of beach material, silt discharge, etc., will be collected on a continuous basis for the planning and design of shore protection works.
- iii) Causes of erosion will be properly identified so that the most effective remedial measures are adopted. The causes of coastal erosion can be accounted for largely by collecting necessary data about waves/tides, sea level changes and by monitoring monsoon vagaries and human interference.
- iv) The impact of coastal protection works on the existing conditions will be studied prior to their planning and implementation. Similarly, infrastructure development will also be subjected to environmental impact assessment. Care will be taken to preserve and protect ecological, aesthetic, historic and archaeological resources.
- v) The impact of coastal protection works on the natural sediment transport system will also be taken into consideration as negative, down drift



impact on the local and regional sediment budget.

- vi) Any remedial measures will be taken up after proper investigation and scientific studies to assess their techno-economic viability and suitability of site. It will be ensured that protection measures do not shift erosion problems from one site to another (refer section 5.10).

[Action: SDMAs/DDMAs; Ministry of Shipping and Transport]

- 20. Coordination among these multiple stakeholders with MoEF as the primary focal point, will be strengthened (refer section 5.10).

[Action: MoEF]

- 21. Strategies will be evolved for protecting standing crops (refer section 5.12.2).

[Action: Ministry of Agriculture; ICAR; Ministry of Rural Development; state agriculture universities; coastal states/UTs]

- 22. The following strategies will be evolved for protecting cultivable land from salinity:

- i) Restrictions will be imposed on utilisation of agricultural lands for aquaculture, which will be confined to brackish water areas identified for that purpose.
- ii) Pumping of brackish water into fresh water areas for aquaculture will not be permitted.
- iii) Pumping of groundwater for fresh water aquaculture will be restricted to avoid depletion of fresh water resources (refer section 5.12.3).

[Action: MoEF; coastal states/UTs]

- 23. Coordinated efforts will be made for protection of livestock, cattle and poultry. (refer section 5.12.4, 5.12.5).

[Action: Ministry of Agriculture, ICAR, coastal states/UTs]

- 24. A regular mechanism of providing due assistance to weaver community of coastal states/UTs need to be established by the Ministry of Textiles. State Governments of coastal states will consider construction of some cyclone shelters in weaver community dominated villages situated in coastal low lying areas, with their ground floor to serve as community weaving facility (refer section 5.13).

[Action: Ministry of Textiles, coastal states governments/UTs]

## 5.15 Implementation Strategy and Time-Frame

### 5.15.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

5.15.2 Following is the time-frame for implementation of the activities listed in this chapter:



### Time-frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commencement	Action and Date of Completion
1	Mapping and delineation of coastal wetlands, patches of mangroves and shelterbelts, identification of potential zones for expanding bio-shield spread based on remote sensing tools	DoS, MoEF, MoES, Sol-NSDI, SDMAS, state remote sensing agencies	2008-09	2009-10
2	Regulate the infrastructure and development activities in coastal zones	MoEF, SDMAS, coastal area development authorities	2008-09	2009-10
3	Monitoring of water quality and carrying and assimilative capacities of the open water with institutionalised remedial measures	MoEF, SDMAS, river water authorities, CGWA, state GWBs	2008-09	2009-10
4	Develop ICZM frameworks for addressing sustainability and optimal utilisation of coastal resources apart from cyclone impact minimisation plans	MoEF, SDMAS, coastal area development authorities, state remote sensing agencies	2008-09	2011-12
5	Evolve eco-system restoration plans for degraded ecological zones	SDMAS, MoEF	2008-09	2011-12
6	Development of delta water management and freshwater recharge/management options	SDMAS, River water authorities, coastal area development authorities	2008-09	2010-11
7	Coastal bio-shields spread, preservation, restoration/regeneration plans	MoEF, SDMAS, coastal area development authorities	2008-09	2011-12
8	Implementation of coastal flood zoning, flood plain development and flood inundation management and regulatory plans	MoEF, SDMAS, coastal area development authorities	2008-09	2011-12
9	Ground water development and augmentation of fresh water requirement in coastal urban centres	MoEF, SDMAS, river water authorities, CGWA, state GWBs	2008-09	2011-12

# 6

## Awareness Generation

### 6.1 Overview

6.1.1 In the context of DM, awareness generation should have two objectives. First, it will prepare communities to deal with disasters in a manner that people's lives and properties are protected, and to ultimately become resilient.

6.1.2 Second, public awareness generation will serve to empower people with knowledge about the role and responsibilities of the state, leading to crystallisation of political and administrative will. This will manifest itself in better and timely strategies for disaster risk reduction.

6.1.3 Awareness encompasses a wide range of modes of sensitising communities, neighbourhoods and various functionaries from the local to the national level. Targeting schools, colleges and all educational institutions is a very important part of awareness generation. The diverse groups of youth evolve into responsible citizens. Awareness has to be cultivated as a way of life. It has to be sustained through constant updating, upgrading and mock drills. Such preparedness helps innovation and adaptation, including restoration, of traditional/indigenous wisdom. Awareness will also help in induction of the constantly evolving knowledge of science and technology as well as research and development applications.

6.1.4 A holistic plan of action encompasses enrichment through interaction on an international scale of insights, experiences and innovations. The diverse range of disaster situations that India experiences is essentially continental and oceanic in nature, with complex socio-economic and cultural

variables. Such a holistic perspective helps to develop a rich framework of (a) capacity analyses and (b) community preparedness. It is noteworthy that a rich variety of initiatives have already been set in motion by a network of institutions in India at the national, state and local levels, both in the private and public sectors.

### 6.2 Awareness Programmes

6.2.1 The awareness programmes will generally cover early warning services and understanding of its products and service deliverables for effectively responding to the emergency. It will also bring out all preparedness measures prescribed for before, during and after the cyclones by taking into account various do's and don'ts. For instance, one such important measure is the preparation of a 'Safety Kit' by every family before a cyclone. On the other hand, it is also necessary to know about mainstreaming mitigation and the risk reduction options along with developing partnerships in the upkeep and maintenance of lifeline infrastructure for use during emergency situations and for impact minimisation plans. Cyclone risk mitigation demands a close and simultaneous coordination among the target audience at:

1. **Household Level:** especially women, children, elderly and disabled.
2. **Community Level:** civil defence groups, women's Self Help Groups (SHGs) etc., youth clubs and other social, cultural organisations and NGOs,.
3. **Institutional Level:** educational institutions and district/local level authorities.

## 6.3 Community Awareness

6.3.1 All these target audiences have to continuously interact and coordinate according to the community level preparedness and emergency response plans.

- i) **Expected levels of awareness about cyclone risk will at least include:**
  - a) Details of areas in the vicinity which are vulnerable to cyclones.
  - b) Various aspects of cyclone awareness: impacts and checklist of elements that can be prepared for and learning to mitigate their risks.
  - c) Mainline media focusing on sensitising timely action.
  - d) Focusing on skill development through ground-level disaster preparedness programmes across the target audience groups.
- ii) **Perceived mental/psychological barriers of individual households to being addressed by the government and community awareness groups include:**
  - a) Feeling of helplessness in the disaster affected areas and feeling of complacency in other areas.
  - b) Cyclones are part of the local DNA, so low credibility is given to any message from NGOs/government/any other agencies.
  - c) Lack of ownership, i.e., an attitude of considering that is Government's problem and not my problem'.
  - d) Many a times, four out of five cyclone warning signals do not actually result in a cyclone.
  - e) Loss of land which is illegally occupied.
  - f) Loss of income.
  - g) Insecurity of women and children in cyclone shelters.
  - h) Poor arrangements for food and sanitation in cyclone shelters.
- iii) **Focused elements of awareness across target audience groups are:**
  - a) Content of the mainline, local and vernacular media will be focused on timely response, assigning responsibility to the concerned communities and removing complacency.
  - b) Actionable communication will be achieved through real-life local success stories and consequences of inaction, etc.
  - c) Training and skill development will be very high to ensure a basic level of readiness.
- iv) **Key considerations for an effective visual media awareness campaign are:**
  - a) All TV channels and local cable networks will be covered.
  - b) Have a sequence of episodes depicting a story on cyclone awareness.
  - c) Slot during the highest viewership programmes like films/popular TV programmes, local cable networks.
  - d) Create a strong emotional flavour of local linkage in the documentary.
  - e) The theme will be based on the case study of a few bravery stories related to cyclones.
- v) **Key considerations for an effective radio-based awareness campaign are:**
  - a) The frequency of airing the warning will be half the number of news programmes aired every day.

- b) Design quiz questions related to cyclone awareness.
  - c) Arrange toll free numbers for facilitating live participation/interaction by the target audience groups.
  - d) Identify the standardised case study templates for ease in capturing such real-life events.
- vi) **Other possible awareness options that are to be employed for effective local level cyclone risk awareness campaigns include:**
- a) Video on wheels.
  - b) Local display options: banners/posters, display boards, bus back/bus stand wall panels, etc.
  - c) Local theatre groups.
  - d) Puppet shows and road shows.
  - e) Skill-based competition programmes in schools/public gatherings/group discussions.
  - f) Documentary telefilms (10–15 minutes duration).
  - g) Mock drills and simulation exercises.
  - h) Pamphlets, brochures and handouts.
  - i) Song and drama division of Prasar Bharati for street plays, etc.
  - j) Exhibition on cyclone themes.
  - k) FM/community radio campaigns.
  - l) Mapping and transfer of best practices: newsletter based on risk mapping of districts and village clusters along with periodic feedback as per the pre-determined format.
- vii) **Linking awareness with the techno-legal regime**
- Awareness about the need for strengthening enforcement of the techno-legal framework

is to ensure that the provisions of the DM Act, 2005, bye-laws and zoning regulations, etc., through appropriate CBDM and Disaster Risk Management (DRM) programmes. This will involve:

- a) The need to modify various existing provisions of safe and sustainable developmental regulations has to be recognised. This has to take into account hazard resistant designs, preservation of bio-shield buffer zones, land and water resource management, upkeep standards of lifeline infrastructure, SOPs, mitigation action plans, etc. The advantages of all such actions will be clearly explained to and understood by the people. It is only then that better compliance would be possible.
- b) Formulating risk reduction developmental action plans, contingency plans and institutionalise mock drills (table top and live) in sectoral departments based on local needs.

- 1) Awareness generation will become a mandatory component of DM plans of all ministries of GoI and the concerned line departments of coastal states and UTs, including State Information Commission rates.
- 2) Design and development of appropriate awareness modules will be carried out by states/UTs under the general guidelines of NDMA.

viii) **Knowledge integration, management and dissemination**

Knowledge integration, management and dissemination are critical components of the technical capacity development to be

accomplished by building partnerships and developing networks with all knowledge and S&T institutions on a continuous basis. Lack of technical capacity enhancement of domain-specific skills can severely paralyse the DM infrastructure and administrative mechanisms. Design and development of relevant educational and communication campaigns and launching them from time to time is important.

ix) Institutionalise capacity enhancement

a) The institutionalise capacity enhancement at all levels of government, in particular, is essential in the ever-changing risk profile of the various vulnerable zones in view of the recurrence of multiple hazards. Necessary enforcement mechanisms to update/revisit DM plans of the region in the post-disaster scenario, by virtue of the changed risk profile, are to be put in place, specific to the various principal institutional partners in risk management. Accordingly, suitable changes are required in respect of mitigation (reduction of disaster risk and vulnerability to future disasters) and recovery that are concerned with the safe location and construction of settlements/infrastructure related to public works, housing, rural development, water, energy, transport, etc. Mechanisms will have to be put in place to provide timely and relevant information to the affected communities on different aspects of the reconstruction programme, including policies, plans, procedures and entitlements; and also enable the communities to voice their concerns and provide feedback.

b) The reconstruction programme also presents an opportunity to raise

awareness of other natural hazards and promote appropriate disaster risk management practices. Experience with natural disasters indicates that some of the most effective risk management actions — both anticipatory (reducing future risks) and compensatory (preparedness to respond)—need to be taken at the local level. The reconstruction programme presents an opportunity to provide greater impetus to local-level risk management and to enhance the emergency response preparedness of the communities.

The main issues related to institutionalise capacity enhancement are:

- 1) Networking of academic research with stakeholders in the government and the community, thus enabling appropriate domain skill enhancement.
- 2) Creating a repository and cyclone-specific information database for multi-sector risk mitigation efforts and carrying out capacity analysis based on international best practices.

## 6.4 Community-Based Disaster Management (CBDM)

6.4.1 Sensitising the community about cyclone risk would be an important plank of the CBDM strategy. The mitigation aspects of the disaster need to be clearly identified and disseminated. The meteorological aspects of cyclones need to be demystified and communicated to the coastal communities in an appropriate culture friendly manner. ULBs and PRIs need to be fully familiarised with early warning logistics. Focus will be on all this percolating to the households at the grass-root level.

6.4.2 Imparting knowledge regarding the do's and don'ts during actual response to disasters is a major challenge. Further, communities need to be sensitised about the importance of bio-shields, construction of shelters, ownership by and involvement of communities in the management and maintenance of the shelters and the amenities therein.

6.4.3 As per the DM Act, 2005, planning for disasters is to be done on a decentralised basis on a village to district model. The planning for DM will enlist horizontal partnership of the community which has to be sought through well recognised techniques like participatory rural appraisal, focused group discussions, etc., involvement of ULBs and PRIs, NGOs, SHGs and all CBOs and, most importantly, the vulnerable groups which are most likely to be affected. Historical knowledge of past disasters and traditional coping skills need to be incorporated in the plans that are to be prepared at various levels.

6.4.4 Capacity-building of stakeholders on other parameters of cyclone DM will include search and rescue, medical preparedness, drawing up of micro plans at the block and village levels, camp management scenarios, incident command systems (ICS), special dispensation for vulnerable groups, participatory damage assessment, etc. Multi-layered and multi-hazard training modules also need to be devised for this.

6.4.5 The minimum standards of relief and response would need to be clearly spelt out after due consultation with the concerned client groups. A humanitarian and rights based approach with due concern for the dignity of the persons affected by disasters will permeate the dispensations and provisions made for the affected people. Dispensations under National Calamity Contingency Fund (NCCF) and CRF would need to be reviewed to see what can be added in the context of current realities. Similarly, relief codes and disaster codes

of state governments would need to be reviewed to ensure that relief is provided on a meaningful and rational basis, and encompasses all possible relief scenarios in rural and urban settings.

6.4.6 School education and safety is an important area through which awareness regarding disasters can be generated. Awareness generation on disasters can be done through a structured syllabus approach and play settings. Mock drills and simulation exercises would also be very relevant. The need for appropriate eco-friendly environment initiatives needs to be highlighted.

6.4.7 Volunteerism will be encouraged from within the community. These volunteers could be enlisted and trained through different organisations like the Civil Defence, National Cadet Corps (NCC), Nehru Yuva Kendra Sangathan (NYKs), NDRF and other CBOs. Lists and addresses of all the volunteers will be maintained at the panchayat/ward levels and their availability factored in the block- and village-level plans for DM. The database on volunteers would need to be updated at a given periodicity which would help in planning capacity development of volunteers.

6.4.8 Protocols and resources of International Red Cross (IRC)/UN agencies on community DM will be utilised in a focused and planned manner.

6.4.9 CBDM activities will become a mainstream activity duly budgeted and appropriately niched in the panchayat and district administration apparatus. ULBs and PRIs would be ideally suited for CBDM initiatives in the states at different levels in so far as empowerment of local bodies is concerned. CBDM activities will find a place in the plans prepared at the district, block and village levels.

6.4.10 Standard platforms for convergence at district and sub-district levels would need to be created with NGOs, corporate, service and trade sectors, CBOs and other stakeholders. Convergence

with other stakeholder departments with social mandates would also need to be generated like Rural Development, Health, Drinking Water and Sanitation, Social Justice and Empowerment, Food, Public Distribution, etc., to orient them regarding their collective responsibilities in DM. A similar exercise would need to be done with respect to various service departments of coastal states/UTs.

## 6.5 Major Action Points

6.5.1 Public awareness generation leads to crystallization of political and administrative will to organise necessary support actions on the ground to build disaster resilient communities. Different target groups will be addressed by developing suitable programmes according to the local needs of awareness, with the help of local/international NGOs and CBOs; with the full support and involvement of governments of coastal states/UTs. A system of regular upgrading of awareness and sensitisation modules and campaigns will be built, involving all stakeholders in the community and the local government. All line departments of the state governments will develop appropriate action plans to support DDMA's in building the highest level of community preparedness with regard to the risks associated with cyclones. Some of the prioritised components of cyclone related awareness modules among communities are discussed below.

### 1. Early Warning

- i) Increasing awareness about the interpretation of early warning and advisories relating to cyclones.
- ii) Enhance disaster preparedness among the vulnerable population, particularly with reference to proper utilisation of early warnings.

### 2. Communication and Response

- i) Increasing awareness about different modes of early warning communication and dissemination.
- ii) Build community-based early warning, dissemination mechanisms along with

appropriate response strategies focusing on safety to life, property and livestock.

- iii) Notify all vulnerable points in and around habitation zones with prominent benchmarks with regard to surge/flood inundation as well as the safe zones of rehabilitation (shelters/schools/ places of worship).
- iv) Evolve village-level response plans through participatory methods and also based on lessons learnt from past cyclones.
- v) Organise safety kits for the vulnerable families to cope with the impact at the family level.
- vi) Develop mock drills to ensure a well prepared community response infrastructure with well defined roles and responsibilities of various stakeholders.

## 3. Structural Measures

- i) Create awareness that cyclone shelters will be used as multi-purpose community centres with regular maintenance so that they are always ready for relocating affected people through a community-based approach.
- ii) Create awareness about identified safe public buildings like schools, community halls, places of worship, etc., and the need for them to be properly maintained so that they can serve as shelters in the event of a cyclone.
- ii) Develop awareness with regard to cyclone resistant building designs based on local-scale vulnerability so as to inculcate the culture of safe construction among the communities.
- iii) Generate full knowledge of the techno-legal and techno-financial regime among the communities with regard



to the allocation of some portion of local area development funds, like MPLADs, for retrofitting of lifeline buildings (like schools, hospitals, all-weather roads, approach bridges, etc.).

- iv) Create awareness about the need for proper maintenance to ensure designed capacity of irrigation canals and drains through active community participation, including involving of command area water users' associations.

#### 4. Coastal Zone Management

- i) Generate awareness about the significance of protecting mangroves and shelterbelts surrounding the vulnerable habitations, for protecting coastal communities from the fury of cyclones, coastal storms, tidal waves and tsunamis.
- ii) Popularise policies and incentives of afforestation so that both ecological security and income security of the communities are safeguarded. Encourage communities to adopt traditional methods of sustainable land

use and reclamation of wasteland and degraded forestland, agro-forestry, organic farming, environmentally sustainable cropping patterns and efficient irrigation techniques.

- iii) Encourage adoption of groundwater recharge schemes by the communities to combat high vulnerability of salinity intrusions causing permanent damage to freshwater aquifers
- iv) Spread the culture of eco-system and biodiversity conservation among school children through formation of eco-clubs in schools.

### 6.6 Implementation Strategy and Time-Frame

#### 6.6.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

6.6.2 Following is the time-frame for implementation of activities listed in this chapter.

#### Time-Frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commencement	Action and Date of Completion
1	Community preparedness based on cyclone early warning	MHA, SDMAs, DDMAAs, Local Bodies, NGOs	2008-09	2009-10
2	Awareness raising with regard to emergency response to cyclone warning communication and dissemination	MHA, SDMAs, DDMAAs, Local Bodies, NGOs	2008-09	2010-11
3	Awareness raising with regard to the structural safety measures	MHA, SDMAs, DDMAAs, Local Bodies, NGOs	2008-09	2011-12
4	Awareness raising with regard to coastal zone protection and preservation	MHA, SDMAs, DDMAAs, Local Bodies, NGOs, MoEF	2009-10	2011-12

# 7

# Disaster Risk Management and Capacity Development

## 7.1 Overview

7.1.1 Paradigm shift in the approach to DM proceeds from the conviction that development cannot be sustainable unless disaster mitigation is integrated into the development process. It has been universally accepted that returns on investments on mitigation are very high. It is usually said in the context of disaster risk reduction that you pay something for doing and pay much more for not doing. Developing appropriate coping strategies and risk reduction plans along with greater awareness of how to reduce risks is the high priority agenda for the DM in India. This will be based on:

- i) Enhancing national, state and local scale advocacy partnerships and knowledge management for mainstreaming disaster risk reduction.
- ii) Standardising hazard risk management tools, methodologies and practices.

## 7.2 Issues of Cyclone Disaster Risk Management

7.2.1 Vulnerability will be considered in a broad context encompassing specifically human, socio-economic and environmental dimensions that relate to social inequalities based on age, gender, ethnicity and economic divisions. Disaster risk reduction strategies include enhancing institutional capacities and operational abilities based on local scale vulnerability analysis and risk assessment. Further, assessing the vulnerability of lifeline infrastructure is crucial to the sustainability of the social and economic sectors.

7.2.2 Sharing information and experience for the purpose of public awareness and imparting professional training of disaster managers in all forms of education is essential for creating a culture of safety and capacity development. Infusion of proven scientific knowledge with the state-of-the-art spatial, security, ICT and location technologies are central to local-scale cyclone disaster risk management by interfacing micro-level details such as topographic, thematic, demographic and socio-economic information. Details of contrasting approaches to the management of cyclone are presented below:

## 7.3 Vulnerability Analysis and Risk Assessment

7.3.1 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. The cyclone vulnerability analysis of Indian coasts has been dealt with, in detail, in the first chapter.

## 7.4 Estimation of Possible Inundation Levels

7.4.1 Shallow bay, low flat coastal terrain and highly varying bathymetry and high astronomical tides are the characteristics of the east coast, especially above 15°N latitude up to the Krishna River mouth. Consequently, even moderate cyclones generate high storm surges. Further, projected climate change induced sea level rise at the village scale level will be taken into consideration for

Table 7.1 Contrasting Cyclone Management Approaches

Rescue and Relief Centric Approach		Holistic DM Approach
<ol style="list-style-type: none"> <li>1. Primary focus on hazards and disaster events</li> <li>2. Single, event-based scenarios</li> <li>3. Basic responsibility to respond to an event.</li> </ol>	<b>Emphasis</b>	<ol style="list-style-type: none"> <li>1. Primary focus on vulnerability and risk issues</li> <li>2. Dynamic, multiple risk issues and development scenarios</li> <li>3. Fundamental need to assess, monitor and continuously update exposure to changing conditions</li> </ol>
<ol style="list-style-type: none"> <li>4. Often fixed, location-specific conditions</li> <li>5. Command and control, directed operations</li> <li>6. Established hierarchical relationships</li> <li>7. Often focused on hardware and equipment</li> <li>8. Dependent on specialised expertise</li> </ol>	<b>Operations</b>	<ol style="list-style-type: none"> <li>4. Extended, changing, shared or regional, local variations</li> <li>5. Situation-specific functions</li> <li>6. Shifting, fluid and tangential relationships</li> <li>7. Dependent on related practices, abilities, and knowledge base</li> <li>8. Specialised expertise, squared with public views and priorities</li> </ol>
<ol style="list-style-type: none"> <li>9. Urgent, immediate and short time frames in outlook, planning, attention, returns</li> </ol>	<b>Time Horizons</b>	<ol style="list-style-type: none"> <li>9. In addition to short term measures, moderate and long time frames in outlook, planning and returns</li> </ol>
<ol style="list-style-type: none"> <li>10. Rapidly changing, dynamic information usage, often conflicting or sensitive</li> <li>11. Primary, authorised or singular information sources, need for definitive facts</li> <li>12. Directed, 'need to know' basis of information dissemination, availability</li> <li>13. Operational/public information based on use of communications</li> </ol>	<b>Information use and Management</b>	<ol style="list-style-type: none"> <li>10. Accumulated, historical, layered, updated, or comparative use of information</li> <li>11. Open or public information, multiple, diverse or changing sources, differing perspectives, points of view.</li> <li>12. Multiple use, shared exchange, inter-sectoral use of information</li> <li>13. Nodal communication</li> </ol>

adopting appropriate cyclone risk mitigation measures, coastal developmental planning and sustainable natural resource management.

7.4.2 Probable Maximum Storm Surge (PMSS) at different places along the east and west coasts of India are presented in the *Vulnerability Atlas of India* [See map in Fig. 1 (b)] based on past cyclone landfall characteristics of 100 years. PMSS estimates indicate that along the east coast, the

surge varies from a high of about 12.5 m near Contai in West Bengal to a low of about 2.5 m near Visakhapatnam in Andhra Pradesh. Along the west coast, the highest PMSS of about 5 m have been estimated in the Gulf of Cambay region and the least near Thiruvananthapuram (about 2 m). Surge varies from place to place; the variations are not linear and at some places, variation of surge between two points close to each other are very large, underlining the importance of computation

of PMSS at very close spacing utilising high resolution surge models on priority. Coastal inundation is mainly due to (a) Storm surge, (b) Variation of astronomical tides along the coast, (c) Wave set up and (d) High water level in the rivers and estuaries/lagoons/lakes due to heavy rainfall caused by cyclones.

- i) The magnitudes of PMSS will be obtained at different points along the coasts in close spacing (village scale) in order to estimate the extent of inundation by using the integrated framework of cyclone storm surge, rainfall-runoff, river flood and GIS-based inundation models.
- ii) High resolution (at least 0.5 m interval) coastal land contour data in digital form (DEM) will be created to precisely determine the extent of inland inundation.

### 7.4.3 Coastal Storm Surge Observation Systems

7.4.3.1 Surge observations are obtained at fixed tide gauge stations along the coast inland bays and islands by using various measuring techniques like tidal staff or poles and tide gauges. At present there are 28 tide gauges installed in various ports of India and maintained by Sol. Such tide gauges are not really meant to measure sudden rise of sea level of high magnitude like storm surge. Recently, through a special project, the GoAP has installed five scientific surge recorders at a few places under APHM & ECRP.

7.4.3.2 Coastal creeks serve as pathways for coastal rivers—which are flooded from upstream during a cyclonic storm—flowing into the sea. These also serve as pathways for inland storm surge inundation from the coast during a cyclonic storm. Scientific surge recorders installed along the coastal creeks will be able to gauge the storm surge from downstream as well as river flooding from upstream flowing into the sea. In the absence of scientific surge recorders, one has to depend mainly on the

available post cyclone survey data and their analysis, which are undoubtedly subjective.

7.4.3.3 Under the tsunami monitoring programme of MoES, the density of tide gauges is planned to be enhanced from 28 to about 60. It is to be mentioned that the tide gauge network of Sol would be of great help in monitoring sea level changes along the Indian coasts. Data needs to be automatically recorded and transmitted to forecasting centres on a real-time basis.

- i) Highest priority will be accorded to the establishment of a telemetric network of automated scientific surge recorders, with a density of 1–5 nos. for each coastal district, depending upon number of creeks and past recorded surge variability.
- ii) In addition to scientific surge recorders, graduated chemical-coated poles (to serve as surge recorders) are to be erected as prominent benchmarks in villages along with sign boards covering all low lying coastal villages.

## 7.5 Estimation of Maximum Possible Damage

7.5.1 Cyclones cause large-scale damage due to associated wind, storm surge, rain and inundation. To deal effectively with cyclone DM, estimation of the maximum possible damage becomes a critical component. One of the major requirements is a local-scale inventory of the following factors:

- i) Vulnerable population.
- ii) Inaccessible/remote coastal villages without safe shelters.
- iii) Number of vulnerable coastal habitations.
- iv) Number of cyclone shelters.
- v) Multiple usage of public buildings with functional requirements.
- vi) Road connectivity to cyclone shelters.

- vii) Requirement of special care to address the needs of children, women, physically challenged and other vulnerable sections including old age people.
  - viii) Details of habitation scale housing vulnerable to wind damage and inundation, and the population living in them.
  - ix) Details of different categories of power and communication towers, roads, culverts and bridges, condition of coastal canals and drains, saline and river embankments and bio-shields.
  - x) Details of pre- and post-cyclonic season data on crops and livestock.
- local wisdom into risk analysis. The information thus generated will be useful in the preparation of long-term disaster risk reduction action plans and optimum land use plans with community participation at survey number level. In this manner, all 13 coastal states and UTs will be on the same cyclone risk management platform.

Village Information System will have to be developed using high resolution satellite images/ aerial photos and socio-economic data covering natural resources and infrastructure facilities on an appropriate scale (1:10000/1:8000) at survey number level using remote sensing and GIS techniques.

## 7.6 Studies Undertaken

7.6.1 Efforts to quantify local scale hazard risk and vulnerability with the available inputs have been taken up by the governments of Andhra Pradesh and Gujarat in the recent past. However, there is a requirement of standardising procedures and database—both spatial and non-spatial. The objectives of the studies will be:

- i) Wind Hazard Mitigation and damage estimation of
  - a) Surface wind circulation pattern.
  - b) Wind hazard model for quantification of damage.
  - c) GIS based Decision Support System (DSS) for generating hazard maps.
- ii) Inundation maps along with provision of diversion drains.
- iii) Land use planning.

## 7.7 Village Scale Risk and Vulnerability

7.7.1 Assessment of vulnerability at the village level is to be carried out through community based strategy and institutionalising ingestion of traditional/

### 7.7.2 Hazard Risk Zoning and Mapping

7.7.2.1 The foregoing efforts will enable the development of Micro-Scale Hazard Vulnerability and Risk Zoning maps and classification of all information on priority. This will provide a basis for development of appropriate mitigation options and effective utilisation of funds for holistic risk reduction.

#### Elements of Vulnerability Reduction

The key elements of a Long-Term Vulnerability Reduction Plan are:

- A) Disaster Risk Identification (Hazard Risk and Vulnerability Assessment)
- B) Disaster Risk Reduction (Mitigation and Regulation)
- C) Disaster Risk Transfer (Relief and Insurance)

Additional elements of the effort include:

- i) Capacity analysis of district/taluk/block level stakeholders in government and community to manage disasters.
- ii) Evolving well-defined disaster mitigation measures (structural/non-structural) in all pre-

and post-disaster actions. The emphasis in disaster mitigation is on critical aspects such as safe location, safe design and safe construction of new structures, infrastructure and settlements. Based on the hazard-risk-vulnerability assessment, standard mitigation measures will be readily identified and adopted for existing key infrastructure.

- iii) Identification of appropriate regulatory actions required for ensuring compliance with regard to disaster mitigation by considering the vulnerability levels and the existing regulations in place.
- iv) Review of existing land-use and building regulations procedures/practices to identify appropriate disaster mitigation measures.
- v) Mechanism for disaster risk transfer through community based informal micro finance/micro credit and micro insurance arrangements.
- vi) Incentive mechanism for siting/relocating infrastructure to safe locations.
- vii) Cost-Benefit analysis of cyclone disaster impacts and mitigation options.
- viii) Updating the existing SOPs in the Cyclone Contingency Plan of the states/UTs and review of Relief Codes.
- ix) Institutionalising clearly defined roles and responsibilities of all key agencies (government/non-government).

implementation of application software with all defined linkages with natural disaster specific data and information management. The main components of the required support systems of real-time DSSs are fail-safe and seamless communication infrastructure, data distribution and data management systems to evolve emergency response, relief routing and rehabilitation planning during the disaster. This is necessary for DRM through local scale vulnerabilities, risk mapping and mitigation planning for sustainable development, including sustenance of land and water resources. Communication systems will provide real time data and information to support control centres and operating agencies related to disaster monitoring, mitigation and enforcement. Sub-components of risk management support systems are:

- i) Data Distribution Centre (DDC).
- ii) Data Validation Centre (DVC).
- iii) Data Processing and Application Development (DPAD).
- iv) Decision Support System to cater to the requirement of pre, during, post disaster activities, scenario development, mitigation planning, etc.

### 7.8.2 National Database for Mapping Attributes

7.8.2.1 Developing application services and DSSs requires considerable application software development and GIS specific activity, which calls for an adequate number of specific systems and tools. The implementation of DSSs is sustainable only when backed up with national level high-end infrastructure comprising:

- i) High end computing.
- ii) Storage and communication network.
- iii) 3-D Virtual reality visual studio.

## 7.8 Spatial Decision Support Systems for Cyclone Management

### 7.8.1 National Database for Emergency Management (NDEM)

7.8.1.1 The development objective of an effective disaster risk management framework involves



- iv) Centralised comprehensive databank for Cyclone Risk Management with nodes in various coastal states/UTs over a fail-safe communication backbone with NDMA, SDMAs / DDMAAs, EOCs.
- v) State-of-the-art Command/Control Operations Centre for effective coordination of disaster response actions.

7.8.2.2 High-end computing, visualisation, networking and communication command control infrastructure will essentially carry out data fusion involving collating, analyzing, interpreting, translating and monitoring of EW from line departments, based on state-of-the-art technology. Impact assessment and emergency response management systems developed under HDSS are used for generating EW based impact assessment scenarios for response planning and mitigation and risk reduction based developmental planning. Implementation of HDSSs for customised multi-lingual warning generation and dissemination into decision making actions in a scientific manner at different administrative levels can lead to effective relief and rehabilitation planning by various line departments of the local government. The HDSS can also assist in organising and/or mobilising necessary response resources by SDMAs/DDMAAs. Development of such a system becomes particularly useful when the community's reaction to a warning immediately translates into increased demand on public services.

7.8.2.3 Further, it is necessary to include cost-benefit analysis for all coastal states/UTs as part of DSS that would allow the losses and costs to be normalised for changes in population, wealth and inflation in the affected areas. To maximise the usefulness of such cost-benefit analysis, the database of DSS will include the expenses associated with TC warning and information services and mitigation efforts as well, including the vulnerability and societal impacts of TCs.

- i) The preparation of NDEM by DoS will be expedited to cover all the cyclone vulnerable coastal districts on priority.
- ii) The database required for mapping different district/sub-district level attributes will be made accessible to all concerned departments/agencies/stakeholders.
- iii) Integration between hardware and software will be ensured for compatibility and interoperability of computing, visual and networking infrastructure nodes at the centre and state/district levels.
- iv) Ingest traditional/local wisdom into the risk analysis framework of DSS.
- v) Coastal ULBs/PRIs will workout micro-level analytical tools with appropriate interfaces to DSSs for planning and executing suitable risk reduction activities.

### 7.8.3 Augmentation of Additional Surveys by the Census Commissioner

7.8.3.1 The requisite quantification of the socio-economic vulnerability requires additional attributes of individuals and households, viz. type of housing, perception of risk, senior citizen-managed households, single women-headed households, etc., that are not available from census data that is updated for every 10-year period in India. As a matter of fact, no such comprehensive household-scale information is available, except that some of the parameters are specifically generated over selected pockets for development indicators. Also, several indicators pertaining to human resource development and developmental mitigation planning are required to be bundled as a part of census attributes.

- i) Amend the Census Act, 1948 in order to carry out additional surveys for generating disaster-specific attributes to fully address all aspects of DM.



- ii) Until then, specific additional surveys can be organised in a pilot mode to firm up the proof of concept identifying targeted vulnerable groups/households; planning of additional cyclone shelters and storage of essentials, etc., to plan for targeted relief operations.

## 7.9 Cyclone Disaster Management Information System

7.9.1 The establishment of a comprehensive Cyclone Disaster Management Information System (CDMIS) covering all phases of DM is highly essential to provide online services to the departments of DM in the states. Initially a review has to be carried out on the availability of digital data, existing infrastructure and requirements for creating a database for coastal cyclone/flood prone states along the coastline of India. Development of such a comprehensive management information system has to be on the basis of detailed studies encompassing a wide variety of spatial and non-spatial data sets apart from assisting the DM administrative department in planning and monitoring progress of mitigation works. Various components of CDMIS are listed below:

- i) Hazard, risk and vulnerability (with village level hazard maps of storm surge inundation and wind hazard, along with the quantification of vulnerability and associated risk and identification of vulnerable groups).
- ii) Cyclone EW and lead time spatial hazard maps.
- iii) Inventory of Infrastructure in coastal 20 km stretch developed by engineering departments (Irrigation; R&B; Urban Development; Agriculture; Power etc.) and monitoring of maintenance of existing infrastructure and new mitigation works for long term-risk reduction.
- iv) Bio-shield Inventory and Monitoring of Plantation/regeneration in identified gap areas.
- v) Assessment of the pre-disaster status of crops and livestock census.
- vi) Damage assessment in a post-disaster scenario, including standardisation of post-cyclone survey formats.
- vii) Hazard DSS support for emergency response, relief routing and rehabilitation/evacuation planning.
- viii) Support for sensitisation and awareness raising, including simulation exercises and mock drills.
- ix) Appropriate visual support tools for all phases of the disaster cycle, viz. preparedness, prevention, mitigation, relief, rescue, rehabilitation and recovery.
- x) Desktop interface for DM administration for exploring; probing and updation of core and disaster specific data sets with common format of inventory.
- xi) Support for management and maintenance of lifeline infrastructure (cyclone shelters, hospitals, schools, places of worship, etc.).
- xii) Management support for monitoring the maintenance and execution of critical mitigation projects.
- xiii) Directory of DM authorities at all levels – resources and contact details of all stakeholders (government; NGOs, elected representatives in Parliament, Legislatures, ULBs/PRI, etc.).
- xiv) Documentation support for a) all past cyclones, b) reports prepared and compiled by independent groups and agencies and c) planning future programme and R&D initiatives for improving cyclone risk management capabilities.

## 7.9.2 Data Providers for Disaster Risk Management

7.9.2.1 The dynamic nature of an emergency situation calls for timely updating of a variety of required data/information from various organisations as no individual agency can produce and update all the required information (calling for partnerships with a data sharing and data exchange mindset). The main data types that are to be acquired for DM in this country include:

### Static Data Providers

- i) National coverage of topographical maps on all scales of Sol topo-sheets.
- ii) National coverage of geological maps on all scales of the Geological Survey of India (GSI).
- iii) National coverage of hydrology maps on all scales of the Central Groundwater Board (CGWB).
- iv) River command area and basin maps of CWC.

### Dynamic Data Providers

- i) National coverage of soil maps on all scales of the National Bureau of Soil Survey and Land-use Planning (NBSSLUP).
- ii) National coverage of forest maps on all scales of FSI.
- iii) National coverage of land-use maps, wasteland maps, urban maps, groundwater potential maps and other thematic maps of NRSA on all scales.
- iv) National coverage of coastal land-use maps of MoEF.
- v) Census maps and census data of the Census Department.
- vi) National Thematic Mapping Organisation (NATMO) maps and atlases.

- vii) National coverage of satellite images of all resolutions by NRSA.
- viii) IMD's data.
- ix) Naval Hydrographic charts of the Naval Hydrographic Office (NHO).
- x) CWC data.
- xi) Data from state government departments regarding, irrigation, agriculture, mines, minerals, etc.
- xii) Data from the Ministry of Transport.
- xiii) Data from MoES pertaining to coastal and marine area management.

7.9.2.2 The above data sources list is only illustrative and not an exhaustive list of known agencies providing data of relevance to DM. Data may be available in various forms in many other departments/organisations/industry/NGOs. Data resources of various agencies have to be studied in detail and mechanism will be evolved for ensuring that this data, whenever relevant, becomes an authentic part of the national data for disaster risk management.

- i) Standards and interoperability protocols will be implemented by stakeholders.
- ii) Logically, all the producers and updating agencies manage their sectoral datasets during their everyday business and emergency situations. If the results of such data production and updating efforts are physically recorded, the required data/information for disaster response is always available to the producer. If this information is shared and exchanged, datasets will be accessible to a wider emergency management community.
- iii) A committee set up by NDMA will be empowered to review the data needs and make datasets available to all stakeholders for holistic DM.

Table 7.2 Current Efforts for Core Spatial Data Generation in the Country

Agency Responsible with Augmentation of Resources	Areas of Priority	Scales of Spatial Data
<p><b>Survey of India</b></p> <ul style="list-style-type: none"> <li>• MoEF is funding a Vulnerability Line Mapping pilot project. Project completion to be expedited and to be scaled up for the entire coastline</li> <li>• Eleventh Plan Working Group recommended for funding 1:10000/1:8000 scale digital topographic fields for all multi-hazard zones (coastal areas to be taken up on priority)</li> <li>• 1:25000 scale coastal topographic maps are generated under Department of Ocean Development Funded Project. Digitisation work to be funded on priority</li> <li>• 1:50000 scale data digitisation is near completion under NSDI Programme Initiative</li> <li>• High Altitude Airstrip project will provide the capability for not only establishing communication network but also carrying out continuous imaging with different sensors of the affected areas with large footprint of 500 km diameter, needs to be funded on priority in the Eleventh Plan</li> </ul>	<p>84 districts vulnerable to cyclones [mosaic of digital topographic layers is to be generated for facilitating sub-district scale hazard, risk and vulnerability assessment required for holistic cyclone risk reduction strategy]</p>	<ul style="list-style-type: none"> <li>• 1:2000/1:4000 scale in metro cities/urban areas in coastal areas [Coastal seaward stretch of Vulnerability Line/Setback Zone]</li> <li>• 1:8000/1:10000 [Coastal seaward stretch falling beyond Vulnerability Line and up to 10 km inland]</li> <li>• 1:25000 [Coastal seaward stretch falling beyond 10 km inland and up to 20 km inland; To cover complete delta areas]</li> <li>• 1:50000 [Coastal district areas beyond 20 km inland]</li> </ul>
<p>NDEM Initiative of Department of Space (part-funded by MHA)</p> <ul style="list-style-type: none"> <li>• 1:50000 scale digital topographic, thematic, infrastructure and natural resources fields are completed for about 60 multi-hazard districts</li> <li>• 1:10000/1:2000 scale efforts are slated for the Eleventh Plan. Efforts on priority for coastal belt need to be funded</li> <li>• Procurement of Airborne Laser Terrain Mapping infrastructure with aircrafts, sensors and instrumentation/communication needs funding support in the Eleventh Plan</li> </ul>	<p>84 districts vulnerable to cyclones</p>	<ul style="list-style-type: none"> <li>• Digitization of thematic, infrastructure and natural resources are to be taken up for all districts vulnerable to cyclones on priority at 1:50000 scale</li> <li>• 1:10000 scale digital topographic, thematic and many other fields for urban areas of more than 1lakh population and all river basins</li> <li>• 1:2000 scale digital topographic, thematic and many other fields for mega cities</li> </ul>
<p><b>Necessary to integrate the efforts of Sol and DoS under NSDI, NDEM and MoEF initiatives for speedy completion of digital spatial data generation for holistic risk management</b></p>		

NSDI: National Spatial Data Infrastructure

7.9.2.3 To achieve this objective, the required information for DM will be recognised and a CDMIS framework established. The responsibility of maintaining the information will be shared between different organisations based on a) appropriate and accepted policies; b) appropriate standards for the production of data; c) the training of people to work with these datasets; d) the establishment of an appropriate network and software tools for exchanging and sharing information/data and e) appropriate policies for accessing and using data/information. Specific core data requirements and the ongoing efforts in this regard are summarised in Table 7.2.

### 7.9.3 Disaster Specific Datasets

7.9.3.1 With respect to cyclone disasters, apart from core datasets, the following disaster specific datasets are required for the coastal districts of the country.

with various departments will enable the formulation of strategies and guidelines for generating/updating the database and its subsequent organisation. It will facilitate in:

- i) Identification of spatial datasets and attributes required to be generated and/or refined.
- ii) Development of semi-automated or automated tools for data conversion and organising them in accordance with NSDI and NDEM spatial frameworks.
- iii) Development of automated tools for database validation adhering to the NSDI and NDEM database standards.
- iv) Design of standard lookup table templates in order to avoid inconsistencies across various departments.
- v) Generation of predefined symbols for various spatial datasets.

Type of Data	Attribute	Application	Source
Floods occurred due to cyclones	Frequency, likely impact statistics on areas affected, crop area, population, livestock, houses, public utility	Flood hazard/risk map with zone and likely impact scenario	Data providing organisations: CWC/DoS
Cyclones	Frequency, cyclone parameters, likely impact statistics on areas affected, crop area, population, livestock, houses, public utility	Likely landfall points	Data providing organisation: IMD
Urban floods due to cyclones	Frequency, likely impact statistics on areas affected, crop area, population, livestock, houses, public utility	Flood hazard/risk map with zone and likely impact scenario	Data providing organisations: CWC/DoS
Cyclones	Landfall and storm surge	Intensity, wind speed, pressure, SST	IMD/MoES
	Damage assessment map	Damaged areas, damage statistics	States and DoS

### 7.9.4 Updation of Database through Additional Surveys

7.9.4.1 A detailed analysis of inventory of spatial database and relevant attribute information available

7.9.4.2 Micro-Administrative Scale Inventory Construction/Renovation of Coastal Canals

- (i) Present status of coastal canals and drains.

- (ii) Number of villages that do not have proper irrigation canals and drains.
- (iii) Number of villages affected by damaged irrigation canals and drains in the past.
- (iv) Assessment of the need, requirement of canals/drains (length in km) to be renovated/newly constructed.
- (v) Assessment of the need, requirement and the number of canals/drains locking gates and sluices to be renovated/newly constructed.
- (vi) Involvement of the community and other departments while assessing these needs.
- (vii) Key issues such as location of cyclone-prone areas, alignment selection, design criteria, range of tests to be carried out, renovation/construction methodology, etc.

#### 7.9.4.3 Construction/Renovation of Saline Embankments

- (i) Present status of saline embankments/locking gates and sluices.
- (ii) Number of villages that do not have saline embankment/locking gates and sluices.
- (iii) Number of villages affected by damaged saline embankments/locking gates and sluices.
- (iv) Assessment of the need, requirement of saline embankments (length in km)/number of locking gates/sluices to be renovated.
- (v) Assessment of the need, requirement of saline embankments (length in km)/number of locking gates/sluices to be constructed.

#### 7.9.4.4 Shelterbelt Plantation Zones

- i) Present status of shelterbelt plantation zones in the states/UTs.

- ii) Area to be covered further, along with gap areas.
- iii) Existing efforts for shelterbelt plantation/other schemes being implemented.
- iv) Strategies for intensive plantation/issue of irrigation, wind/resource and time exhaustive scheme.

#### 7.9.4.5 Roads, Culverts and Bridges

Roads are always associated with culverts and bridges, as the terrain demands, to make them fit for use throughout the year. While selecting a bridge site, factors like (i) permanency of the channel, (ii) presence of high and stable banks (iii) narrowness of the channel and average depth compared to maximum depth, straight reach of the stream (both upstream and downstream) of the proposed site, freedom from islands both (both upstream and downstream), possibility of right-angled crossings, good approaches, etc., are to be given adequate attention so as to keep them functional in the event of any disaster.

- (i) Present status of road links in cyclone prone areas.
- (ii) Number of villages not linked with all-weather roads in cyclone prone areas.
- (iii) Assessment of the need, requirement and road (length in km) to be constructed.
- (iv) Assessment of the need, requirement and the number of culverts and bridges to be constructed.
- (v) Involvement of other departments while deciding assessment needs.
- (vi) Key issues such as location of cyclone prone areas, site selection, design criteria, range of tests to be carried out, construction methodology, etc.

#### 7.9.4.6 Vulnerable Housing, Power and Communication Network Towers

- (i) Details of habitation scale thatched houses, tiled roof houses, sheet roofed houses, etc.
- (ii) Details of population living in vulnerable house types.
- (iii) Tehsil-level details of the length of different categories of power and communications towers along with their design standards and structural details.

Research and Development Organisation (DRDO), Bhabha Atomic Research Centre (BARC), etc. [especially for Chemical, Biological, Radiological and Nuclear Agencies (CBRN) agencies] and the states have their own specialised institutions which can play important roles in various aspects of managing different types of disasters. It is obvious that each disaster, thematic intervention and phase of the DM cycle requires the type of expertise which though is normally available with multiple agencies; no single agency yet has all the requisite expertise and background.

### 7.10 Capacity Development

7.10.1 Capacity building is a complex exercise that has to be performed on a continuous basis. It needs to cover all aspects of the DM continuum, including prevention, preparedness, mitigation, relief, rehabilitation, reconstruction and recovery for all thematic areas and all disasters. A vital area requiring special attention is upgradation of the efficacy of specialised emergency response capabilities through NDRF and State Response Forces. This effort requires coordination with several stakeholders, including central ministries/ departments, the states and S&T institutions, ULBs/ PRIs, CBOs as well as the corporate sector.

7.10.2 No central ministry or agency by itself is in a position to help the states in capacity development and upgradation of infrastructure required for the management of disasters. The DM Act provides this mandate to NDMA to coordinate and ensure the implementation of policies and plans; a major part of which is related to capacity building.

7.10.3 Many organisations have different roles to play in capacity building. The NDRF and Civil Defence, for instance, will have the pivotal role in community capacity development. Similarly, the central ministries and nodal agencies, niche organisations such as the Armed Forces, Defence

7.10.4 Capacity development generally encompasses various layers of governance by the central and state governments, district administration, local authorities, ULBs/PRIs integrating seamlessly with the activities of the community, civil defence teams and NGOs. Components of the multi-layer capacity development framework are: i) Training; ii) Techno-legal framework; iii) Knowledge management; iv) Institutional capacities and v) Capacity analysis and assessment studies. Hence, capacity development revolves around several factors such as: (a) appreciation and awareness of the causes and consequences of disasters, including native wisdom, (b) acquisition of skills and abilities to be able to act and cooperate in times of imminent or actual mass emergencies, (c) caring for the young, pregnant women, old and disabled.

7.10.5 Training is the essential and central activity of the overall capacity development programme. Appropriate training programmes are to be conceived and conducted at all levels and involving the entire spectrum of stakeholders (from government/NGOs and community) to fully address the needs of sensitisation, knowledge/information management and skill development of the DM functionaries in particular. Listed below are some specific areas of intervention for cyclone related training and capacity enhancement.



Table 7.3 Intervention for Cyclone related Training and Capacity Development

Targeted Outcome	Special Areas of Intervention	Agencies/Sectors to be Involved with Resource Linkages
Training for services/cadres/agencies involved in mitigation, preparedness or response	<ul style="list-style-type: none"> <li>• Training needs analysis/HRD Plan along with strengthening faculties of DM in ATIs.</li> <li>• Drawing up of capsule courses for training.</li> <li>• Training of trainers in technology adaptation.</li> <li>• Training of block/village level staff/volunteers and ULBs/PRIs.</li> <li>• Strengthening of the DM machinery under the state DM Commissioners.</li> </ul>	<ul style="list-style-type: none"> <li>• NDMA and SDMAs</li> <li>• Lal Bahadur Shastri National Academy of Administration (LBSNAA), Mussourie</li> <li>• NIDM and ATIs</li> <li>• Engineering training Institutes/Academics in states</li> <li>• National Institute of Rural Development (NIRD) and State Institute of Rural Development (SIRD)</li> <li>• NDMA and SDMAs</li> </ul>
Training of IAS/IPS, State Administrative Service Officers/State Police.	<ul style="list-style-type: none"> <li>• Crisis management during the cyclone period.</li> <li>• Emergency operations and natural resources management.</li> <li>• ICT interfacing for disaster response.</li> </ul>	<ul style="list-style-type: none"> <li>• National Institute of Security Academy (NISA), Police Training Academies, ATIs and SIRDs</li> <li>• Lal Bahadur Shastri National Academy of Administration, Mussourie</li> <li>• NIC and academics in states</li> </ul>
Engineers/Architects	Curriculum for undergraduate engineering courses to be updated to include cyclone hazard mitigation technologies.	All India Council for Technical Education/IITs/Professional bodies and Councils in states
Health Professionals	Crisis management, emergency medical response/recovery and trauma management at Diploma/UG/PG levels.	Ministry of Health & Family Welfare (MoH&FW)
Youth organisations (NCC, NYS, Scouts and Guides and NSS)	Disaster response, search and rescue in their orientation capsules.	NDRF and Ministry of Sports and Youth Affairs; Ministry of Defence
School curriculum	Updation of DM curriculum periodically with more visual tools and virtual reality training modules.	Central and State Boards of Education
Mass media campaign for awareness raising	<ul style="list-style-type: none"> <li>• Design and development of a region specific communication strategies.</li> <li>• Use of visual and print media.</li> <li>• Development of modules on mitigation, preparedness and response.</li> </ul>	NDMA and SDMAs



Awareness generation, disaster preparedness and mitigation planning	<ul style="list-style-type: none"> <li>• Development of network of NGOs and voluntary bodies at state and district levels in an hierarchal manner for multi-layered capacity enhancement by integrating government efforts.</li> <li>• Co-opt NGOs in the evolution of local developmental planning and response mechanisms at all levels.</li> </ul>	NDMA, SDMAs, NIDM and ATIs
Networking of Corporates	Planning and joint execution of Emergency Response Action Plans.	NDMA, SDMAs, FICCI, CII, ASSOCHAM, etc.
Raise the level of ATIs' programmes	<ul style="list-style-type: none"> <li>• DM faculty to be nodal point of capacity enhancement in the states to liaise with all departments of the states.</li> <li>• Designing and supervision of the technical capacity programme initiatives of line departments.</li> <li>• Evolving of suitable training modules by taking up the specific needs of the line departments in consultation with knowledge institutes.</li> <li>• Undertake research studies, design and conduct mock drills to improve preparedness and response capacities, design and development of DM databases, etc., to meet the emerging needs of the states.</li> </ul>	NDMA, SDMAs, NIDM, Ministries of S&T, Earth Sciences, Environment, Water Resources, etc.

### 7.10.6 Use of DSS for Capacity Development

7.10.6.1 It is necessary to increase our understanding of the coastal environment in terms of the threats posed by natural hazards as well as by long term/ongoing climate change and rise in sea level. DSS will facilitate the creation of flood risk maps, flood depth maps, erosion risk maps, economic impact assessments, and a set of action plans. The result of the application of these tools and processes would be for developing full understanding of the hazards, risks and vulnerability of coastal areas and the steps to be taken to avoid

or ameliorate the effects of such changes or events. Further, such an integrated solution will help address the need for risk assessment and mitigation in support of insurance, real estate and financial institutions, as well as engineering firms and municipalities for effective management of land resource. Scientific capacity analysis of multi-sector stakeholder departments can bring out the present-day constraints of DM plan implementation and provide the opportunity to strengthen technical capacities and augment appropriate institutional mechanisms.

## 7.11 Community Capacity Building

7.11.1 Based on international efforts and past experience, CBDM is found to be the best mode of developing ground-level emergency responses and coping strategies (pre-disaster/disaster/post-disaster) since communities and families are the first responders during the crisis. United Nations Development Programme (UNDP) formulated DRM programmes to enhance the coping capacities of communities to deal with disasters. The DRM programme is a national initiative to reduce vulnerabilities of communities in some of the most hazard prone districts of India (241 districts in total, although 169 are currently covered).

Suggested Actions for Strengthening CBDM Efforts:

- i) The UNDP–DRM Programme covers 64 coastal districts. The remaining 20 districts will also be brought under the programme. However, if any district is left out, the state governments can formulate similar programmes and implement them.
- ii) In order to achieve the same levels of community preparedness and coping capacities in all the districts, it is necessary to re-launch a programme similar to the present UNDP–DRM programme, after it is completed, by addressing all the shortfalls in its earlier implementation, as observed in certain districts.

7.11.2 The approach of the DRM programme is to: a) focus on building community capacities, community based planning b) partnership with all stake-holders in DM, such as governments, professional bodies, training institutions, peoples’ representatives, technical institutions, etc. and c) boost capacities at all levels, with special emphasis on women, to address disasters through an integrated approach for reducing vulnerabilities. Thematic focus is on education, training and capacity building for better preparedness and mitigation in terms of DRM and recovery at the

community, district and state levels by strengthening linkages with SDMAs and DDMAAs.

7.11.3 The approach to conducting of mock drill varies according to the complexity of the scenario and also depending upon the potential hazards, response system of the institution and the target community. Therefore, to ensure proper implementation of a drill programme, roles and responsibilities of the concerned personnel, departments, corporate bodies, stakeholders and mechanism for conducting the drill will be delineated clearly.

Suggested Efforts for Enhancement of DM Capacities:

- i) DM Cells of ATIs and SIRDs are to work in with close coordination with DM Commissioners of the respective states.
- ii) DM Commissioners are to make efforts to ensure full attendance of the expected stream of officers in various DM training programmes by close monitoring.
- iii) Strengthening of the techno-legal framework will form an essential part of technical capacity development at all levels of government and other stakeholder groups, including communities. This can be taken into account while addressing DM curriculum issues in general and for engineers/architects in particular.
- iv) Necessary technical, organisational and preparedness support required for local DM activities will be tapped from the India Disaster Knowledge Network (IDKN) built under the DRM project.

### 7.11.4 Role of Civil Society

7.11.4.1 Most of the coastal NGOs came into existence since 1977 as a response to the call for cyclone relief. Today, the NGOs have graduated from being mere relief organisations to focusing on

rehabilitation, reconstruction and mitigation. They have formulated and grounded community-based indigenous coping mechanisms such as low-cost floating aids, grain banking and disaster fund. They have developed methodologies in facilitating community-drawn comprehensive contingency plans including resource, vulnerability, social mapping, etc. The NGOs have integrated disaster mitigation as a component of the development programmes they have initiated. Livelihood options are being explored as an important ingredient in the coastal development process and programmes. Women's SHGs, CBOs and other grass-root organisations are involved in the disaster mitigation process. Community media is being used as a tool to spread awareness. Government resources are also being tapped so as to work in coordination with them for optimum utilisation of resources. It is in this background that a strategic collaboration between the institutions of states and of civil society has to be worked out in order to facilitate better community-based disaster response.

#### 7.11.4.2 Village Task Force/Village Volunteer Groups

The community being the first to be affected and the first to respond in the case of cyclone disaster, there is a need for constituting Village Task Force (VTF)/Village Volunteers Group (VVG) for the efficient management of disasters. A trained VTF/VVG will enhance the capacity of the villagers to cope with immediate needs in the case of cyclone disasters striking the area. Village volunteers will be selected by ULBS/PRIs/CBOs/NGOs from their own locality based on their past experience and knowledge of the people living there and their ability to take part in relief, rehabilitation and rescue activities at the village level. Emphasis needs to be given to women volunteers in the development of village DM plan. Specialised training needs to be given to the identified groups for enhancement of skills to effectively carry out their responsibilities such as warning dissemination, systematic evacuation, search and rescue operations, shelter

management, first-aid, trauma counselling, damage assessment, etc. The training needs to be on a continuous basis. New volunteers need to be chosen at certain intervals of time. These volunteers will also take part in the preparation of DM Plans for the villages and awareness programmes related to cyclones to be carried out in the area.

#### Suggestions for Establishing Effective Community Level First Responder Support:

- i) Constitute teams consisting of ex-servicemen, retired police personnel, paramilitary forces and residents' welfare associations (RWA) to serve as neighbourhood support groups in organising necessary assistance through local police and emergency services.
- ii) Civil defence teams could operate as mobile teams and impart training to local communities with the help of DDMMAs.
- iii) Involve various youth organisations namely (a) NCC, (b) National Service Scheme (NSS), and (c) NYKS to have the inherent advantage of outreach at the grass-root level and also have the advantage of ready availability for immediate assistance at the ground level in the event of any disaster.
- iv) Network the efforts of civil defence teams with that of ULBs and PRIs for ensuring sustainability of the disaster preparedness initiatives at the local level.
- v) Schools and colleges run by the government and private sectors are to constitute DM Clubs in coastal areas to enhance greater awareness and coping capacities to deal with all aspects of cyclones, including developing appropriate school emergency response plans.
- vi) Create trained VTF/VVG in each coastal village to prepare at the local level to deal with all phases of cyclone DM.

- vii) Develop emergency response plans for hospitals and government offices.

## 7.12 Handling Societal Impacts of Tropical Cyclones

7.12.1 TCs, with their triple threat of high winds, storm surge, and heavy rains, can bring devastation to coastal areas of the country. The societal impacts are numerous and depend upon factors such as cyclone intensity, the area impacted (topography and bathymetry), the local and regional economy, the state of development, community demographics, the status and integrity of physical and social infrastructure, and household and community wealth, to list but a few. Reports of WMO/ESCAP suggest that on an average, approximately 1145 people die or go missing, nearly 700,000 houses are destroyed, and about 1,500,000 people are left homeless every year as a result of tropical storms. The direct financial losses were estimated to be US \$ 3.6 billion annually. These statistics, although profoundly revealing, do not include the significant indirect, and often less tangible and more difficult to quantify, associated societal impact on individuals, families and communities.

7.12.2 Second-order impacts from disaster response actions and medical problems can occur days to weeks after the event. Third-order impacts from changes in tax revenue and land-use can occur months to years later. It is easy to identify some of these impacts, but often difficult to quantify and/or qualitatively evaluate them. In India, most TC disasters have occurred in the Bay of Bengal. The deltas formed at the mouth of the various river systems are heavily cultivated and densely populated. These people are poor and their housing and other buildings are generally flimsy, un-engineered and thus are highly vulnerable. When confronted with the threat of a TC they are very

resistant to evacuation because they do not want to flee and leave behind their hard-earned belongings. In recent decades, extensive industrial installations such as ports, steel mills, SEZs/EEZs and nuclear power plants have built in the coastal areas which have more organised SOPs.

7.12.3 The priorities of the poor and those living in subsistence economies are sustenance of their sources of livelihood and securing food, shelter and clothing. When TCs impact the poor, their livelihoods along with their ability to obtain food, shelter and clothing can be significantly disrupted. Coastal communities that do have the capability to feed and provide suitable drinking water to their population can lose this basic capability following a TC. This may have disastrous short-term and long-term effects. Where the ability of communities to withstand and recover from natural disasters is diminished, the application of social protection programmes and policies is required to reduce people's exposure to risks, enhancing their capacity to protect themselves and thus reduce the vulnerability. Increase in property damages and vulnerability of the people due to TCs has largely been attributed to the increase of coastal population, increase of human activities and an absence of a hedging mechanism such as insurance for life and property and risk transfer.

Suitable hedging mechanisms, such as insurance of life and property, need to be evolved to reduce cyclone vulnerability of coastal populations.

7.12.4 The destruction of natural habitats and degradation of natural terrestrial and marine ecosystems can severely undermine the integrity of coastal zone systems. Detailed studies of risk from storm surges, riverine flooding, and wind impacts for a number of coastal cities at the household to community level under various government and university supported projects is imperative.

Vulnerability will be identified and understood with the involvement of scientists and experts. They will also be involved in evolving risk reduction strategies to minimise loss of life and damage to property. SDMAs and DDMAAs will evolve a suitable mechanism to facilitate this.

## 7.13 Documentation of Events

'It hardly needs to be said that organizations cannot learn from failures if people do not discuss and analyze them. Yet this remains an important insight. The learning that is potentially available may not be realized unless thoughtful analysis and discussion of failure occurs.'

Amy Edmondson and Mark D. Cannon, Harvard Business School Paper, 'The Hard Work of Failure Analysis', 22 August 2005.

7.13.1 Every disaster event throws up some 'success' stories. Then there are instances of 'consequences of inaction'. There are also some glaring 'failure' stories.

7.13.2 While most of the time the 'success' stories are well documented, stories about the 'consequences of inaction' and 'failure' tend to be ignored or even covered up. The 'success' stories can serve as an inspiration and must be used in awareness generation campaigns. But the importance of the other two categories should not be undermined.

7.13.3 A lot has to be learnt from failure investigation, particularly in the aviation sector. No efforts are spared to find out the cause, following an aviation accident. The objective is not apportionment of responsibility to penalise or apportionment of liability. It needs to be converted into an opportunity to learn and ensure that such things are not repeated in future.

7.13.4 Faithful and accurate documentation of all aspects of disaster events is essential for creating good historical records that finally become the data source for future research and mitigation planning. In the past, some good efforts had been made by some scientific departments like IMD and administrative departments in the centre and the states as well as individuals. Recently, certain technical groups, DM institutes and NGOs have joined hands in documenting the disaster events in the country.

7.13.5 These are mostly sectoral reports and a comprehensive document taking all facts and figures (scientific, technical, loss and damage and economical) into consideration are not available. Sometimes, the data presented on an individual issue varies widely from report to report. To reduce/minimise such deficiencies, the following remedial measures are recommended.

- i) Post-cyclone survey will be carried out by a 'pre-designated team' comprising experts and officials from concerned scientific, technical, administrative departments and NGOs immediately after a cyclone crossing the coast.
- ii) Remote sensing data will be used extensively for documentation especially, for loss and damage estimation.
- iii) Formats of data collection will be pre-designed for every department /group, so that errors are minimal.
- iv) A comprehensive document will be prepared as soon as possible by the pre-designated department/institution (NIDM/NDMA) involving all the stakeholders and the report be placed on the website/published quickly.

7.13.6 The basic source of data for the preparation of sectoral reports (by any) will be the data compiled by the group of experts, unless there is a valid reason to differ.

## 7.14 National Cyclone Disaster Management Institute (NCDMI)

### 7.14.1 Context

7.14.1.1 The high priority agenda for DM in India is to enhance national, state and local-scale advocacy partnerships with technical capacity enhancements at all levels involving stakeholders from government and community for mainstreaming disaster risk reduction on continuous basis. This effort involves multi-disciplinary activities with cross-sectoral interfaces and by which a framework for standardising hazard risk management tools, methodologies and practices from local, district and state levels have to be established. Further, continuous infusion of proven scientific knowledge with state-of-the-art spatial, security, ICT and locational technologies (Global Positioning System [GPS] and General Packet Radio Service [GPRS]) will form the centre-stage of cyclone disaster risk management involving local-scale, micro-level details such as topographic, thematic, demographic and socio-economic information. Such a mechanism will provide the requisite platform for quantifying and updating a micro-scale cyclone hazard, risk and vulnerability profile on a regular basis.

### 7.14.2 Need Analysis and Justification

7.14.2.1 In the present scenario, most of the coastal states and UTs do not have the desired technical capacities to address all aspects of cyclone risk management in a holistic manner. Hence, there is an urgent need to build capacity enhancement at the local and state levels for institutionalising mechanisms for all-round resilience to cyclone impact, viz. long-term cyclone mitigation, management of coastal zones, sustainability of coastal resources and economic development.

7.14.2.2 Further, no ministry/department at the moment has plans to address this prime

component of holistic cyclone risk management either individually or through an established mechanism. Development of synergy among various S&T departments, knowledge-based and R&D institutions through cross-sectoral initiatives is imperative for holistic cyclone risk management. Such an integrated mechanism needs to be evolved.

### 7.14.3 Major Initiatives to be launched under the banner of NCDMI

#### 7.14.3.1 Steering State-Level Agencies towards Effective Crisis Management

- i) Collection and archival of region specific observations.
- ii) Development of customised spatial and non-spatial datasets at the lowest possible administration level (involving Sol and DoS).
- iii) Development of appropriate tools for local-scale impact assessment based on landfall and intensity forecasts obtained from central agencies.
- iv) Development of fully customised hazard maps in respect of various attributes (viz., houses, infrastructure, crops, power transmission/communication network, roads and bridges, etc.) for facilitating the planning of appropriate strategies by the respective administrative authorities.
- v) Generation of multi-sectoral customised warnings in local languages for community-level response.

#### 7.14.3.2 Local-Level Generation of Customised Cyclone Warning

- i) Evolving appropriate institutional arrangements involving offices of the IMD (State Meteorological Centres), SDMA, DM Commissioner, CWC and other line departments for sectoral customisation of cyclone impact in respect of protecting their infrastructure.



- ii) Preparation of local language, user friendly warnings for facilitating community-based response.

#### 7.14.3.3 Commissioning of High-End Computing, Visualisation and Networking Infrastructure

High-end computing (scalable 30–50 Teraflops peak performance), storage (800 Terabytes) and communication network (Gigabit Ethernet) infrastructure will be commissioned as a central facility with NCDMI with seamless connectivity with SDMAs of 13 coastal states/UTs and DDMA of 84 coastal districts vulnerable to cyclones. It is expected that such a facility would also support the additional capacity enhancement (hazard, risk and vulnerability studies) planned for holistic cyclone risk management in states and districts.

#### 7.14.3.4 Areas of Priority

- i) Developing centralised lead time impact assessment.
- ii) Capability development for mitigation and risk reduction planning for holistic cyclone DM.
- iii) Development and implementation of DSSs for customised warning generation for various sectors.
- iv) Interfacing cyclone impact assessment and the emergency response management system.
- v) Hierarchical Digital Cyclone Track Database.
- vi) Parametric Wind Field and Cyclone Risk Models.
- vii) Building an economic database for Cost-Benefit analysis.
- viii) Formulation of appropriate long-term hazard reduction/mitigation measures to deal with recurring cyclones.
- ix) Formulation of appropriate cyclone hazard mitigation, CZM, resource management,

delta water management and land management plans.

- x) Development of mechanisms for handling societal impacts of tropical cyclones.
- xi) Development of plans for establishing community-level first responder support systems.
- xii) Building a comprehensive CDMIS.
- xiii) Development and support of an appropriate techno-legal framework.
- xiv) Integration of the efforts of Sol and DoS under NSDI, NDEM and MoEF initiatives for establishing a spatial data infrastructure (SDI) platform for cyclone DM.
- xv) Updation of database through additional local-scale surveys for the generation of all attributes of datasets for cyclone risk management.
- xvi) Development of long-term cyclone disaster risk reduction and impact minimisation plans through risk identification, risk reduction and risk transfer mechanism on a micro scale.
- xvii) Design and development of appropriate disaster response platforms.
- xviii) Development of appropriate medical preparedness and response systems at sub-district scales.
- xix) Development of emergency response plans with schedule of actions.

NCDMI will be established as an exclusive institutional set-up in one of the coastal states to address all issues related to cyclone risk. This will involve stakeholders from the government and the community, focusing on preparedness, mitigation and emergency response. NCDMI will bridge the gap in the integration of disaster related technical support of all the concerned departments/ministries of the central government with those of states/UTs and local authorities for effective DRM. NCDMI will



also serve as a platform for all academic and S&T institutions to synergise their efforts to offer better disaster risk reduction options.

NDMA will conceptualise the entire project.

## 7.15 Role of DM Department in States

7.15.1 Gol had, in the past, asked the states to re-designate their Relief Commissioners as Commissioners DM and to have a separate department of DM. This was done with a view to changing the mindset from the earlier focus of a rescue-relief-centric approach to a holistic approach to deal with all aspects of DM covering prevention, preparedness, mitigation, recovery and reconstruction.

7.15.2 Integrated planning at the state level has to mainstream DM with the developmental planning framework in identified areas and bring together decisions/investment activities of several line departments such as Agriculture, Irrigation, Forestry, Roads and Buildings, Power, Panchayati Raj, Rural Development, Urban Development, etc., in a multi-disciplinary and multi-sectoral approach.

7.15.3 There have always been problems in dealing with a multi-sectoral approach. It is very often seen that DM related schemes, plans and programmes are generally accorded very low priority, in most cases, by the respective line departments, in spite of having clearly demarked activities. DM departments in the states/UTs at present have a very limited role in planning and coordinating the monitoring of such schemes, plans, programmes and projects.

The functions of DM departments in the states/UTs will be totally re-oriented to bring them to the centre-stage of all DM related activities. This will facilitate a paradigm shift in the approach to DM to cover all phases. There is a need to steer DM actions—

especially planning and monitoring the implementation of all DM related programmes, schemes and plans of the respective line departments—as they are accorded very low priority in the respective line departments. The role of the DM departments will be redefined to institutionalise such a change.

- i) DM departments will also be closely involved in planning and monitoring the implementation of specific DM related multi-sectoral projects.
- ii) In order to meet such objectives, DM departments will be strengthened with adequate manpower on the basis of the redefined roles and responsibilities.
- iii) Once the role of the DM departments is redefined, all line departments and the entire administrative machinery, in general, have to be properly sensitised about it. This alone can bring about the necessary change in mindset from the earlier rescue-and-relief centric approach to DM to a holistic approach to deal with all DM phases.
- iv) Following are some suggested key priority issues to properly integrate DM with development planning:
  - a) Formulation and implementation of long-term hazard reduction/mitigation measures to deal with recurring cyclones and other disasters.
  - b) Carry out specific cyclone hazard mitigation studies, coastal and delta management, water management, etc., from time to time.
  - c) Involvement of vulnerable communities in the design and implementation of hazard mitigation programmes and management/maintenance of hazard resistant structures.
  - d) Integrate actions and initiatives that have a direct bearing on the

management of coastal zones and upstream watersheds.

- e) Sustainable mitigation activities.
- f) Quarterly review of the implementation of various mitigation activities taken up by the line departments is to be carried out for organising necessary interventions and communicate to NDMA.
- g) Develop a CDMIS with nodes at district/sub-district levels for monitoring the execution of the mitigation activities of line departments and communicate to NDMA.

## 7.16 Major Action Points

1. High resolution (at least 0.5 m interval) coastal land DEM mosaics will be developed for micro-scale delineation of cyclone risk, hazard and vulnerability (refer section 7.4.2).

[Action: DST-Sol; DoS-NRSA; MoEF]

2. An integrated hazard mitigation framework will be developed for cyclone storm surge, wind hazard, rainfall-runoff and river flood modelling on a GIS platform for estimating possible areas and depth of inundation, possible damage to infrastructure, crops, houses, etc., evaluating vulnerability and its changing profile from time to time. A Village Information System will be developed using high resolution satellite images/aerial photographs and socio-economic data covering natural resources and infrastructure facilities on an appropriate scale at survey number level using remote sensing and GIS techniques (refer sections 7.4.2, 7.5, 7.7.1).

[Action: MoES; DoS; State Remote Sensing Agencies (SRSAs); CWC; SDMAs]

3. Telemetric networks with 1 to 5 automated scientific surge recorders will be established for each coastal district depending upon the past recorded surge variability data. Graduated chemical-coated poles will be installed in all low lying coastal villages to serve as additional surge recorders (refer section 7.4.3).

[Action: MoES; coastal states/UTs]

4. The following coordinated actions will be carried out for managing DSSs:

- i. Developing the database required for mapping different district/sub-district level attributes and making it accessible to all departments/agencies/stakeholders.
- ii. Ensuring integrations between hardware and software ensured for compatibility and interoperability of computing, visual and networking infrastructure nodes at the centre and state/district levels.
- iii. Ingesting traditional/local wisdom into the risk analysis framework.
- iv. Building institutional and technical capacities appropriately to work out risk minimisation options
- v. Working out micro-level analytical tools with appropriate interfaces to DSSs for planning and executing suitable risk reduction activities (refer sections 7.8.1, 7.8.2).

[Action: SDMAs/DDMAs of coastal states/UTs]

5. The Census Act, 1948 will be amended in order to generate disaster specific attributes to fully address all aspects of DM. Until then, specific additional surveys can be organised in a pilot mode in a pre-designed format (refer section 7.8.3).

[Action: MHA; states and UTs]

6. Establishing a comprehensive Cyclone Disaster Management Information System (CDMIS) covering all phases of DM to provide on-line services to the Departments of Disaster Management in the states (refer section 7.9).  
[Action: Directorates of Economics and Statistics (DES), State Departments of Information and Communication Technologies (ICT) Planning, Coastal Area Development and Irrigation and Command Area Development Authorities, State Remote Sensing Agencies (SRSAs), Disaster Management Departments of Coastal States and UTs] [Time-Frame: 2008–09 to 2009–12]
7. Ongoing efforts of Sol, DoS under NSDI, NDEM and MoEF initiatives for speedy completion of digital spatial data generation to cover 84 coastal districts vulnerable to cyclones will be integrated on priority for evolving holistic cyclone risk reduction strategies (refer section 7.9.2.3).  
[Action: DST-Sol; DoS-NRSA; MoEF]
8. Strengthening of the techno-legal framework will form an essential part of technical capacity development at all levels of government and other stakeholder groups (refer section 7.11.1).  
[Action: NIDM; BIS; state ATIs]
9. A programme—similar to the UNDP-DRM Programme—will be launched in districts which are not already covered by it (refer section 7.11.1).  
[Action: MHA; state governments/ UTs]
10. NCDMI will be established as an exclusive institutional set-up in one of the coastal states to address all issues related to cyclone risk. NDMA will conceptualise the entire project. NCDMI will:
  - i. Involve stakeholders from the government and the community, focusing on preparedness, mitigation, response, rehabilitation and recovery.
  - ii. Bridge the gap in the integration of disaster related technical support of all the concerned departments/ministries of the central government with those of the states/ UTs and local authorities for effective DM.
  - iii. Serve as a platform for all academic and S&T institutions to synergise their efforts to offer better disaster risk reduction options (refer section 7.14).  
[Action: NDMA; DST-Sol; DoS-NRSA; MoES; CWC; SDMAs]
11. The functions of DM departments in states/ UTs will be totally re-oriented to bring them to the centre-stage of all DM related activities to steer DM related programmes, schemes and plans of the respective line departments and also to be closely involved in planning and monitoring the implementation of specific DM related multi-sectoral projects. The role of the DM departments will be redefined to institutionalise such a change. DM departments will be strengthened with adequate manpower, on the basis of the redefined roles and responsibilities (refer section 7.15).  
[Action: MHA; states and UTs]

## 7.17 Implementation Strategy and Time-Frame

### 7.17.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

7.17.2 Following is the time-frame for implementation of activities listed in this chapter.

#### Time-Frame for Different Activities

S. No.	Important Milestone Activities	Implementing Agencies	Period of Commencement	Action and Date of Completion
1	Integration of mapping and spatial digital data generation activities of various ministries of GoI	NSDI, Sol, DoS, MoEF, SRSAs	2008–09	2009–10
2	Development of CDMIS	Communication Group of NDMA, SDMAs, DoS, Sol, NSDI	2008–09	2009–10
3	Framework development of cyclone hazard mitigation models with DSSs	SDMAs, DoS, SRSAs	2008–09	2009–10
4	Generation of high resolution DEM mosaics for all coastal areas	NSDI, Sol, DoS, MoEF, SRSAs	2008–09	2009–10
5	Generation of various micro-scale cyclone hazard maps	SDMAs, MoES	2009–10	2011–12
6	Development of long-term vulnerability reduction and micro-level development action plans	SDMAs, MoES, SRSAs	2010–11	2011–12
7	Development of appropriate management and technical capacity development plans (Central/state/district/local/PRI)	SDMAs, Urban Development and Coastal Area Development Authorities	2008–09	2010–11
7	Launch of CBDM activities similar to DRM in all areas of cyclone vulnerability	SDMAs	2008–09	2011–12
8	Strengthening of techno-legal framework at state/district/local authorities	SDMAs	2008–09	2010–11
9	Develop emergency response plans along with a system of evaluating emergency preparedness (mock drills) for hospitals and schools in all areas vulnerable to cyclones	SDMAs, DDMAAs	2008–09	2011–12

## 8.1 Overview

8.1.1 Response measures are those which are taken immediately prior to, and following, a cyclone, aimed at saving life and protecting property besides taking short term actions to immediately deal with damage caused by the disaster. For effective response all stakeholders need to have a clear perception about a TC, its consequences and the actions that need to be taken in the event of a cyclone threat. An appropriate DM plan has to be in place, with the roles of various agencies clearly defined, for carrying out all necessary actions prior to, during and after a cyclone.

8.1.2 The ability to effectively respond to cyclones is becoming more critical because various factors like generally high growth of population density in the coastal areas and increasing settlements in high risk area etc., are contributing to greater vulnerability. Therefore specific response strategies have to be established to deal with cyclone disasters through an organised and systematic management framework involving all stakeholders and responder groups. Disasters pose unique problems that are different from the routine emergencies that police, fire, medical and other medical emergency services face on a day-to-day basis. Very often it is the sheer numbers that have to be handled during cyclone disaster that makes the difference. The role of NDRF (see 1.12.3) becomes very relevant in this context, especially for severe disasters causing extensive and wide spread damage.

### 8.1.3 State Disaster Response Force

States are also to constitute the State Disaster Response Force (SDRF) on the lines of the NDRF.

This will be done by training selected personal from the existing state reserved forces. They will be specially trained and equipped to deal with multi-hazard situations. They will be stationed in the cyclone-prone districts to be able to respond to any disaster situation locally. Operational training of SDRF will be carried out by NDRF Battalions (Bns) and advance training, including training of trainers for SDRF, will be done by the NDRF training institutions. Equipment for SDRF can be procured out of the 10% allocation in the Calamity Relief Fund (CRF) earmarked for capacity building.

## 8.2 Disaster Response Mechanism

8.2.1 As discussed in the previous chapters dealing with early warning, communication and dissemination, the ideally holistic disaster response mechanisms comprise many systematic approaches and diverse activities such as:

- i) Developing lead time cyclone hazard impact assessment based on state-of-the-art EWS.
- ii) Developing emergency rescue and evacuation plans.
- iii) Integrating cyclone hazard impact assessment systems with the appropriate warning dissemination systems involving all crisis responder groups in government and communities towards effective response.
- iv) Identifying target populations, especially the vulnerable and disadvantaged, and interacting with them to determine their needs and capacities.
- v) Conducting community level meetings for analysing and mapping their risks and

- planning their responses by scaling up initiatives similar to DRM programmes.
- vi) Fostering the development of communities through monitoring and warning systems for local risk management.
  - vii) Generating public information tailored to target groups and making innovative use of the media and education systems.
  - viii) Establishing local benchmarks and performance standards for warning services.
  - ix) Developing formal mechanisms for public representatives to monitor and oversee warning systems designs.
  - x) Using surveys to measure public awareness and satisfaction.
  - xi) Creating documents, publications, annual events and other anchors of public memory and learning.
  - xii) Providing training on social factors for technical experts, authorities and communicators who operate the warning system.
  - xiii) Conducting research on factors that enhance or impede human understanding of and response to warnings.
  - xiv) Conducting exercises and simulations to enable people to experience and practice warning interpretation and responses.
- 8.2.2 It is important to recognise that all the above activities require coordinated participation of government and voluntary organisations, and communities, bound by a commitment to protect those at risk. Stakeholder roundtables can ensure the required coordination. Core technical agencies—at the national, state and local levels—can play a key role by sustaining such mechanism and supporting them with specialised technical information for triggering the appropriate response actions as shown in Table 8.1.

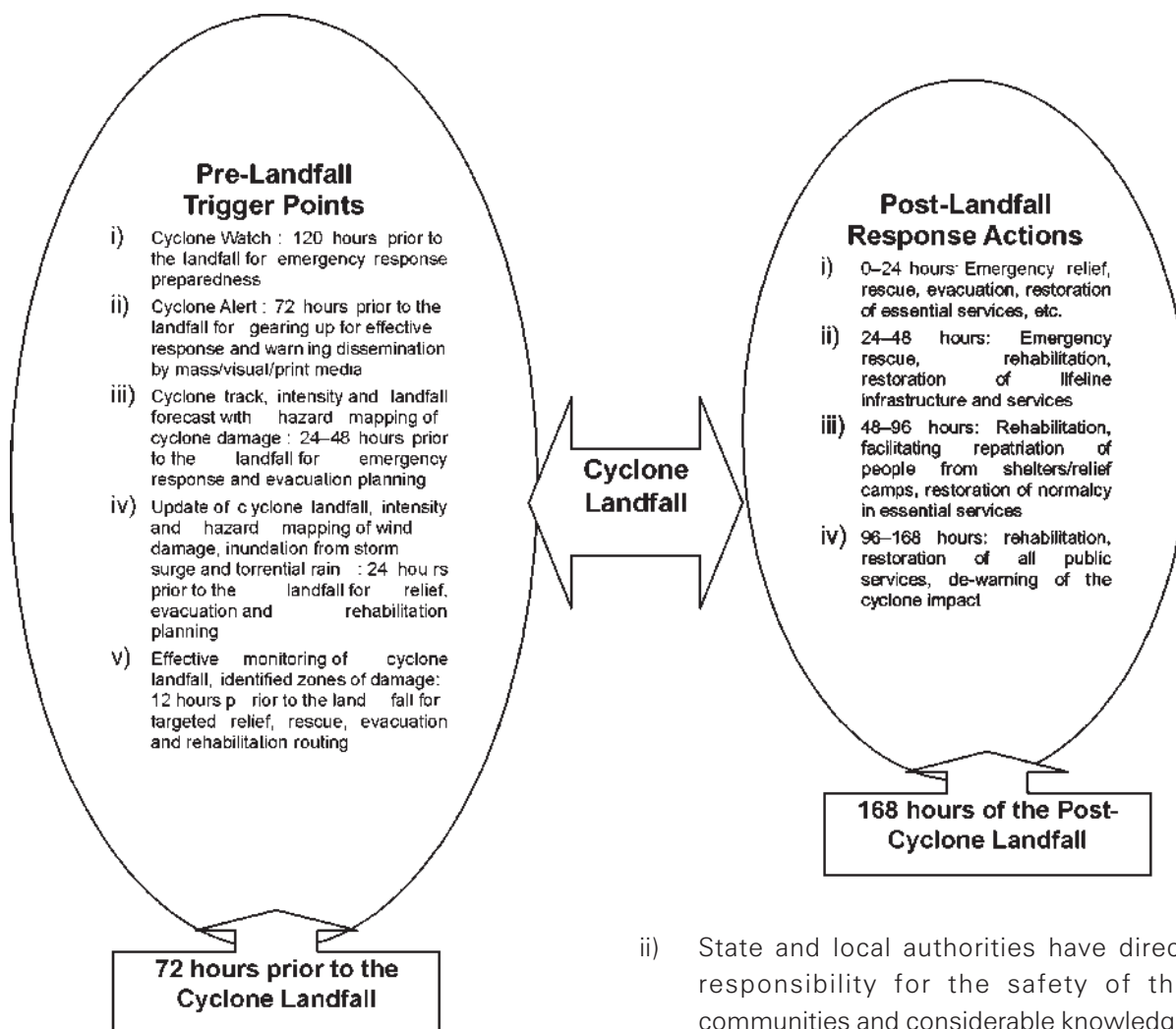
**Table 8.1 Stages of Early Warning/De-Warning**

<b>S. No.</b>	<b>Stages of Early Warning</b>	<b>Disaster Management Actions to be Triggered by Responder Groups</b>
<b>Response Actions Prior to the Disaster Event</b>		
1	Genesis and cyclone watch: 5–3 days in advance	IMD, MHA/NEC, State Executive Committee (SEC)
2	Cyclone alert and clear stage of intensification including possible track: 3 days in advance	IMD, MHA/NEC, SEC
3	Specific track, Intensity, Landfall location and associated coastal lead time hazard impact (storm surge; wind damage; inundation mapping): 2 days in advance with de-warning of safe areas	Emergency response planning by IMD, MHA/NEC, SEC, DDMA's, Community/Civil Defence/NGO Groups; Visual/Print Media

4	Updated track, Intensity, Landfall location and associated coastal lead time hazard impact (storm surge; wind damage; inundation mapping): 24 hours in advance	Emergency evacuation planning, Relief routing and Rehabilitation planning (Govt., national/state DRFs, Civil Defence Teams [CDTs])
5	Specific updates on Intensity, Landfall and associated coastal lead time hazard impact (storm surge; wind damage; inundation; etc.): 12 hours in advance with de-warning of additional safe areas, if any	Emergency evacuation, Emergency preparedness for organising relief, rescue and rehabilitation (Govt., national/state DRFs, CDTs, NGOs, Local Authorities)
<b>Response Actions Following the Disaster Event</b>		
6	Location specific Intense rainfall, Wind, Coastal river discharge inundation (including wave and tidal effects) and hazard impact: Landfall and post-Landfall up to 24 hours later	Emergency rescue, relief and rehabilitation; Restoration of damaged lifeline infrastructure and essential services; Shelters and relief camps; Human safety; Livestock protection (Govt., national/state DRFs, CDTs, NGOs, Local Authorities)
7	Location specific forecast for Relief and Rehabilitation efforts: Post-Disaster (2–7 days) including <b>De-warning of the Disaster</b>	Relief operations; Facilitating repatriation of people from shelters/relief camps; Immediate restoration actions of damaged critical services (Govt., national/state DRFs, CDTs, NGOs, Local Authorities)
<b>De-Warning</b>		
8	Pre-Landfall notification of safe areas by authorities (IMD-Cyclone)	EW actions withdrawn from notified safe areas
9	Post-Landfall notification by authority (IMD)	Cessation of actions by DM authorities



### 8.3 Disaster Response Platform



8.3.1 Developing and implementing an effective Emergency Response Platform (ERP) requires sufficient preparedness with the contributions from all stakeholders and responder institutions. Some of the functions designated to them, for which they are responsible and accountable are listed below.

- i) National-level agencies are required to provide support to local governments and communities to develop their operational capabilities and to translate EW knowledge into local risk reduction practices.
- ii) State and local authorities have direct responsibility for the safety of the communities and considerable knowledge of the hazards to which they are exposed is to be assimilated. As first responder group, they must have complete understanding of the disaster advisory information received and be able to advise, instruct or engage the local population in a manner that increases their safety and reduces the possible loss of community and individual assets.
- iii) NGOs, including voluntary organizations, will have to play a critical role in raising awareness among individuals and organisations involved in ERP at the community level.

- iv) The corporate sector has a diverse and a distinct role to play in ERP as part of their corporate social responsibility. Apart from many other things the private sector has a large untapped potential to help provide skilled services for the communication, dissemination and response elements of EW. They have technical manpower and can play a major role in response.
- v) The S&T community has a central and critical role in providing specialised scientific and technical inputs to assist governments and communities in developing effective ERP. Their expertise is fundamental to analysing natural hazard risks facing communities. They must always be based on state-of-the-art disaster impact analysis and integrated warning dissemination systems.
- vi) The media plays an important role in improving the disaster consciousness of the general population and by disseminating EWs.
- iii) Response strategies for different stages of EW along with activities across the stakeholder/responder groups.
- iv) Mechanism to check/monitor and review grounded response actions and initiate corrective measures.
- v) Social audit of response actions.
- vi) Awareness about regional factors of vulnerability contributing to local cyclone risk enhancement.
- vii) Organise the required tools and machinery for search and rescue operations, clearing of road blocks by fallen trees, debris, etc.
- viii) Ensure the availability of necessary maintenance resources for the restoration and sustenance of essential services.
- ix) Ensure total compliance of SOPs associated with the emergency response cycle.

## 8.4 Linking Risk Knowledge with Response Planning

8.4.1 National capacities for establishing effective ERP are determined by the country's capabilities in science, technology and research; and the availability and sustainability of technologically advanced hazard monitoring networks. Further, it is necessary to institutionalise specific operational procedures at the regional and local levels in respect of:

- i) Preparedness for crisis management and response with a notified calendar of planning and review meetings with all stakeholder/responder groups, including elected public at all levels.
- ii) Random evaluation of emergency preparedness by independent groups ahead of the cyclone season.

8.4.2 A typical ERP dissemination chain involves channelling warnings from technical and scientific sources through government decision makers involving Hazard Decision Support Systems (HDSSs) and the media to multiple receivers who may also function as forward disseminators. Such users include emergency services, security agencies, and operators of utilities, information and communication services, other economic service providers and vulnerable communities.

8.4.3 Current advances in warning dissemination systems in India include SMS, video messaging (MMS) and paging, but future warning transmission systems will have to target the warning only at those at risk and in the vernacular languages. While efforts will continue on improving basic warning message design and dissemination, interest is increasing on how to achieve the multi-organisational change, cooperation and multi-stakeholder interaction needed to engage the

recipients in the dissemination process and thereby make warning messages more effective.

## 8.5 Effective Disaster Response Capability

8.5.1.1. Response to EWs involves activating coping mechanisms mainly for the orderly movement of people out of areas at risk, seeking shelter and safely securing assets, before a disaster strikes. In contrast, post-disaster response implies a wider range of recovery, rehabilitation and reconstruction efforts in the aftermath of disasters. However, both are part of disaster preparedness and employ common emergency procedures. ERP will have clear instructions about the most appropriate actions to be taken to minimise losses to population and assets.

8.5.1.2 India has developed contingency plans at all levels, but traditionally these have mainly focused on post-disaster emergency response and recovery. Community based disaster preparedness (CBDP) can be extremely useful mode of developing ground-level emergency responses and coping strategies (pre-disaster/disaster/post-disaster) since communities and families are the first responders during the crisis. This should be integrated with the efforts of stakeholders in the government at the local level, involving ULBs/PRIs. (The role of the VTF/VVG have already been discussed in 7.11.4.2)

8.5.1.3 Different target groups have varied requirements of measures for preparedness. Individuals need to assess the level of risk they can endure in balancing whether, when and how to react to warnings. Disaster managers need to address whether, when and how to issue warnings, warning content and to ensure warnings reach and are understood by everyone at risk. Customisation of actions based on the lead time impact assessment of EW is to be built in HDSS so that they can facilitate relief routing and rehabilitation planning along with the rational use of resources. Adequate resources

will be made available for timely response in the vulnerable areas. People are more likely to heed and act upon warnings when they have been educated about their risks and have prepared warning-reaction plans. Following are the major issues that are critical to the sustainability of emergency response capacities:

- i) Lessons learned from the experience of the past disaster responses need to be incorporated into response strategies.
- ii) Updating of response plans is to be a continuous process through joint participation of scientific institutions with responder/stakeholder groups.
- iii) Important consideration of disaster managers include determining how safe and adequate public evacuation and other response facilities are, how to effectively move large numbers of affected people safely and how to maintain order and security during evacuations in an integrated manner. In this connection the following need to be kept in mind;
  - a) Special health care support for women (pregnant and lactating), children, the physically and mentally challenged and senior citizens.
  - b) Rescue planning for low-lying areas including night rescue operations in liaison with IAF, Coast Guard, NDRF, CDTs, etc. and
  - c) Early restoration of energy and food supply system.

### 8.5.2 Challenges in Evolving an Effective Response Capability

8.5.2.1 The failure to adequately respond to warnings often stems from lack of planning and coordination at the national and local levels, as well as a lack of understanding by people of their risks. Some agencies may not even understand their roles

and fail to communicate and coordinate effectively. Government machinery may fail to adequately plan for evacuation and emergency shelters for the population unless the gaps of emergency response are fully addressed. National preparedness plans may not reach the entire population, all of whom need to ideally have some basic training, exposure to mock exercises, be aware of their vulnerabilities, and the means to take appropriate action. Some major efforts required in this respect are:

- i) Developing institutionalised multi-agency collaboration with clarity of roles and responsibilities from the national to local levels by defining SOPs at different levels.
- ii) Enhancing organised public awareness and education for early warning response by scaling up DRM projects and awareness campaign initiatives.
- iii) Making it mandatory to organise periodic mock exercises and evacuation drills, on the lines of the pilot initiatives of NDMA for tabletop and live mock drills. Ideally, these should be carried out at all levels and include all agencies, critical facilities, schools, etc., for ensuring effective functioning ERP, taking into account the inventory of community resources and assets.
- iv) Identifying and disposing-of the dead on the basis of local/religious/ethnic requirements.
- v) Setting-up state DRFs for land/sea rescue operations with necessary night rescue support systems training.
- vi) Setting-up facilities for refuelling of helicopters to enable continuous emergency rescue operations in marooned/cut off areas.
- vii) Establishing well-defined post-disaster damage and assessment of recovery needs of the affected communities and support systems.
- viii) Setting up local-level emergency medical response systems for post-disaster scenario to deal with trauma and epidemic control.
- ix) Creating trained VTF/VVG.

## 8.6 Other Supportive Efforts

### 8.6.1 Inventory and Mapping of Locally Available Lifeline and Support Infrastructure

- i) Power transmission towers (220 kw to 11 kw).
- ii) Communication towers: BSNL and other service providers.
- iii) Roads/bridges/culverts network.
- iv) Transport services of police, fire services and transport department; Army/Air Force helicopters/ aircrafts for relief operations; airport/airfield authorities [expected to be coordinated by the DM Commissioner/ Divisional Commissioners].
- v) Health services: local/district/regional state funded hospitals; alternate medical services (Defence/private/voluntary); supply/store of essential and lifesaving drugs.
- vi) Dams and other regulated storage structures: Irrigation and Command Area Departments/reservoir regulation authorities.
- vii) Schools and places of worship (to be developed for use as relief shelters): local authorities/Deputy Commissioners/Divisional Commissioners.
- viii) Food, essential (petrol/gas/kerosene) and relief supply stores: Civil Supply Department; Ministry of Petroleum of Government of India.
- ix) Safe drinking water sources: local urban water supply and rural water supply authorities.
- x) Crops and horticulture sites: Agriculture Department.
- xi) Tourist resorts and infrastructure: Tourism Department.
- xii) Stations of Civil Defence/Disaster Response Forces/voluntary groups.
- xiii) Spatial hazard and damage maps of past disaster events.

## 8.7 Development of Evacuation Plan with Schedule of Actions

8.7.1 Evacuation of human population and livestock is the only prescribed means to save them from the cyclone related damages. On the other hand, evacuation of disaster-affected communities can be one of the most difficult of response operations, especially, when it involves a large population. Evacuation needs to be carried out as a precautionary measure, to be undertaken based on warning indicators prior to impact, in order to protect likely affected communities from the hazard impacts. Evacuation may also be necessary immediately after the cyclone impact so as to move already affected communities to safer locations. For carrying out successful evacuation, continuous dialogue between different stakeholders and responder groups of evacuation with a well-defined coordination plan of actions as listed below are to be institutionalised:

- i) Designing of department specific customised action plans to save lives immediately following or before an emergency in accordance with the local scale cyclone risk profile of the region and to respond to any eventuality/emergency.
- ii) Preparedness plans of all the organisations involved in the emergency evacuation plan (EEP) for all types of emergencies, validate plans, evaluate staff competency and test the established emergency operational procedures.
- iii) Online inventory of emergency rescue and relief resources available with the local government, public and corporate institutions for possible accessing during the emergency (on the lines of DRM initiatives).
- iv) Evolve coordinated EEP institutional mechanism and triggering actions with joint partnership at the state/district level involving all concerned departments and agencies,

armed forces, paramilitary forces, NDRF, civil society, community based organisations (CBOs, ULBs, PRIs, Civil Defence, etc.).

- v) Develop plans for transportation for mass evacuation, need of shelter, health care facilities, etc.

One of the biggest ever emergency evacuation in human history was carried out by the Government of Andhra Pradesh during the May 1990 cyclone by mobilising 2,019 teams and 745 vehicles, which evacuated 6,51,865 people from 546 villages from all the nine coastal districts to 1,098 relief camps.

## 8.8 Medical Preparedness and Response

8.8.1 Cyclones can cause severe damage to the population living in and around coastal areas. The most destructive force of a cyclone comes from fierce winds. Many people are killed and injured when cyclonic winds cause buildings to collapse and house roofs to completely blow away. Most common injuries are crush injuries, spinal injuries, head injuries, fractures, lacerations, contusions and abrasions. Cyclones also result in heavy flooding which may lead to drowning, diarrhoea and related diseases, vector-borne and rodent-borne diseases like malaria, leptospirosis, and skin and eye infections. There is heightened risk of the spread of epidemics in the post-cyclone phase.

### 8.8.2 Preparedness

Proper medical preparedness can significantly reduce morbidity and mortality. Medical preparedness for cyclones includes the following aspects:

- i) Creating awareness to the types of injuries, illnesses and other health problems caused by cyclones to all the medical teams and the community at large. Promoting personal hygiene practices and the use of boiled/safe

- water and food will be part of community education.
- ii) Creating trained medical first responders for providing first-aid to the injured and resuscitation measures for cases of drowning. The medical staff must be trained for cardiopulmonary resuscitation and basic life support for drowning cases. An inventory of trained medical and paramedical staff must also be made available to the district authorities.
  - iii) Medical treatment kits need to be prepared for the management of cyclone casualties. Intravenous (IV) fluid ventilator, oxygen, splint, dressing material, tetanus toxoid drugs, antibiotics, vaccines, anti-snake venom and anti-diarrhoeal drugs will be the most commonly needed medical resources. Sources of availability of large-scale medical supplies must be identified.
  - iv) Patient Evacuation Plan: Emergency medical equipment and drugs must be made available for resuscitation, at the cyclone site. Paramedical staff must be trained for resuscitation, triage and maintaining vital parameters like pulse, blood pressure, respiration and intravenous drip during evacuation. Heli-ambulances need to cater to evacuation of casualties in case of road blocks. The ambulance will have SOPs for treatment procedures.
  - v) DM plan needs to be prepared by all hospitals in the coastal areas. Medical facilities, training of medical personnel, creating awareness about drowning and its management will be part of the plan. Hospitals must nominate an incident officer for coordinating the management for cyclone casualties. Contingency plans must be made ready for capacity expansion of hospitals. Oxygen cylinders, continuous positive air pressure (CPAP), ventilators, splint, dressing material, blood and IV fluids

for transfusion, must be stocked. Hospital casualty rooms will be equipped with resuscitation equipment like suction apparatus, airways, laryngoscope, pulse oxymeter, defibrillator and life-saving drugs. In the aftermath of a cyclone, public health response is one of the prime responsibilities of medical authorities. They must ensure safe water supply and availability of clean food, along with maintenance of hygiene and sanitation through proper bio-waste disposal. Water testing and food inspection is required to be carried out regularly to prevent the outbreak of any epidemic. An effective communication system is an essential requirement for prompt medical response.

### 8.8.3 Emergency Medical Response

For prompt and effective emergency medical response, the Quick Reaction Medical Teams (QRMT) need to be activated so that they reach the cyclone affected site immediately along with resuscitation equipment and life-saving drugs. Cardiopulmonary resuscitation, triage and evacuation work must be done in accordance with laid down SOPs. Enhanced requirements of the medical response teams will be pooled from the government and non-governmental sectors, if required.

### 8.8.4 Medical Treatment at Hospital

A well rehearsed medical preparedness plan would be able to provide intensive care to those rescued from drowning. The emergency medical plan will be triggered immediately on receiving information about any imminent threat of cyclone. Action will be immediately initiated for crisis expansion of the required number of beds. Medical superintendents will be able to forecast the requirement of enhanced manpower and medical stores after knowing the number of casualties likely to be received at the hospital. Special efforts will be made for the



availability of IV fluids, antibiotics, vaccines, etc. Children, women and other vulnerable casualties must be attended to on priority.

### 8.8.5 Mortuary Facilities and Disposal of Dead Bodies

Sufficient capacity will be available in mortuaries to preserve the dead bodies. After proper identification, dead bodies must be immediately disposed through district authorities to prevent any outbreak of epidemic and environmental pollution. Planning for creating makeshift mortuary facilities is also to be carried out for emergency use.

### 8.8.6 Documentation

Documentation throughout the medical response is very important for data collection, records and references. Research programmes, data analysis and follow-up would be used as feedback for lessons learnt and future improvement.

### 8.8.7 Public Health Issues in the Aftermath of a Cyclone

The supply of safe and sufficient drinking water needs to be ensured. Protecting existing water sources from contamination, adding chlorine tablets in water for residual disinfection and provision of latrines and proper waste disposal to avoid contamination through flies and other insects are important steps required immediately in the aftermath of a cyclone. Vector control is done by spraying of shelters with residual insecticides. Provision of insecticide-treated mosquito nets and larviciding are recommended. Immunisation needs to be carried out in susceptible individuals to prevent diseases. Necessary arrangement will also be made to dispose off animal carcasses.

### 8.8.8 Psycho-social Aspects

A large number of victims will have psycho-social effects in the aftermath of a cyclone. The

psychological impact of the cyclone would be manifested as post traumatic stress disorders (PTSD) and other psychological ailments in displaced people due to the cyclone. Counselling has to be provided to them by a team of social workers, psychologists and psychiatrists.

## 8.9 India Disaster Resource Network

8.9.1. Recognising the inadequacy of information on inventory of resources for emergency response, MHA initiated the India Disaster Resource Network (IDRN) in collaboration with UNDP under the GoI-UNDP Disaster Risk Management programme to systematically build up the IDRN inventory as an organised information system. The online information system is hosted at NIC, New Delhi. It can be accessed at the address <http://www.idrn.gov.in>. IDRN is a platform for managing the inventory of equipment, skilled human resources and critical supplies for emergency response. The primary focus is to provide decision makers instant access to availability of equipment and human resources required to combat any emergency situation. The IDRN web site needs to be updated regularly.

8.9.2. As an unique example of public-private partnership in the field of DM, the Confederation of Indian Industry (CII) has also created a web-enabled resource inventory consisting of large records of information obtained from different central and state government departments, agencies and organisations useful for emergency response in the event of any disaster like cyclones, etc. Such activities need to be strengthened and continued.

## 8.10 Major Action Points

1. SDRFs will be set up by the states (refer section 8.1.3).  
[Actions: NDMA; NDRF; SDMA]
2. DM activities of various responder groups from government and community will be



integrated for triggering appropriate crisis management actions through stakeholder roundtables/inter-departmental committees (refer section 8.2).

[Action: MHA; state DM Commissioners; DDMA's/local authorities; NIDM; ATIs; NGOs; Volunteer Groups; etc.]

3. Risk knowledge will be linked with local scale response plans by organising necessary support systems from national agencies in accordance with the needs of the local authorities and community stakeholder groups (refer section 8.4).

[Action: MoES; SDMA's/DDMA's; NIDM; ATIs; local authorities; etc.]

4. Institutionalised multi-agency collaboration will be developed with clarity of roles and responsibilities from national to local levels and periodic updating of SOPs at different levels based on experience gained (refer sections 8.4, 8.5.1).

[Action: States and UTs]

5. A system to determine the safety of relief and relocation infrastructure, capacities of the emergency evacuation machinery and integrated support of emergency health care, night rescue, restoration of energy and food supply, etc., will be institutionalised (refer section 8.5).

[Action: SDMA's in coastal states and UTs]

6. Greater emphasis will be given for public awareness and education for early warning response (refer section 8.5.2.1).

[Actions: NDMA; SDMA's/DDMA's; NIDM; ATIs; NGOs]

7. Facilities for refuelling of helicopters will be set up for continuous emergency rescue operations (refer section 8.5.2.1).

[Actions: States and UTs]

8. Periodic simulation exercises and mock drills will be organised and made mandatory on the lines of pilot initiatives of NDMA for ensuring effective, functional ER along with the inventory of community resources and assets (refer section 8.6).

[Actions: NDMA; SDMA's/DDMA's; NGOs]

9. Emergency evacuation plans will be developed with an institutional checklist of emergency actions (refer section 8.7).

[Actions: NDMA; SDMA's/DDMA's; NIDM; ATIs; NGOs]

10. Local scale emergency medical response systems will be established to deal with medical preparedness, emergency treatment, mortuary facilities and disposal of bodies and carcasses, public health issues including trauma and control of epidemics (refer section 8.8).

[Actions: Ministry of Health & Family Welfare (MoHFW); MCI; states and UTs; NGOs and Corporate Sector]

11. Strengthening of IDR activity with updating of information will be carried out on a regular basis (refer section 8.9).

[Actions: NDMA; MHA; states and UTs]

## 8.11 Implementation Strategy and Time-Frame

### 8.11.1 Implementation Strategy

Various ministries/departments and agencies at the national level and states/UTs will have the responsibility of implementing the guidelines in this chapter.

8.11.2 Following is the time-frame for implementation of activities listed in this chapter.

## Time-Frame for Different Activities

<b>S. No.</b>	<b>Important Milestone Activities</b>	<b>Implementing Agencies</b>	<b>Period of Commencement</b>	<b>Action and Date of Completion</b>
1	Establishment of integrated DM activities of various responder groups	MHA, SDMAs, DDMAAs, ULBs/PRIs	2008-09	2009-10
2	Establish periodic system of evaluation of relief and rehabilitation capacities	MHA, SDMAs, DDMAAs, ULBs/PRIs, NGOs	2008-09	2010-11
3	Establish post-disaster damage and needs assessment procedures from the habitation level	MHA, SDMAs, DDMAAs, ULBs/PRIs, NGOs	2008-09	2011-12
4	Development of emergency evacuation plans	MHA, SDMAs, DDMAAs, ULBs/PRIs	2009-10	2011-12

# 9

## Implementation of the Guidelines: Preparation of Cyclone DM Plans

### 9.1 Overview

9.1.1 The cyclone DM approach aims to institutionalise the implementation of initiatives and activities covering all components of the DM cycle including prevention, preparedness, mitigation, relief, rehabilitation and recovery, with a view to developing communities that are well informed, resilient and prepared to face cyclone-related emergencies with minimal loss of life and property. Therefore, it will be the endeavour of the central and state governments and local authorities, including ULBs and PRIs, to ensure implementation of these guidelines.

9.1.2 For efficient and coordinated management of cyclones, it is vital to evolve appropriate DM plans at the national and state/UT levels. It is equally important to identify various stakeholders/agencies—along with their responsibilities, institutionalise programmes and activities at the ministry/department levels, increase inter-Ministerial and inter-agency coordination and networking, as well as rationalise and augment the existing regulatory framework and infrastructure.

9.1.3 The preparation and planning for responding to a cyclone emergency is to be structured into a coherent and interlocking system. In order to optimise the use of resources and their effective response, the emergency response action plan will include well coordinated and consolidated responsibilities, shared jointly by all stakeholders. Implementation of the guidelines will begin with formulating a DM plan and an enabling phase to build the necessary capacity, taking into consideration of existing elements such as

legislation, emergency plans, stakeholder initiatives, gaps, priorities, needs and the context. To start with, the existing DM plans at various levels, wherever existing, will be further revamped/ refined to address both immediate and long term needs.

9.1.4 The nodal ministry will evolve its DM plans for a holistic and coordinated management of cyclone emergency. To sustain an integrated approach to cyclone DM, the central government needs to make arrangements for implementing the National Plan on an inter-Ministerial or inter-institutional basis so that all the concerned ministries' and stakeholders' interests are represented and all major relevant areas are addressed. The agenda of these guidelines will also be implemented by the governments of the various states and UTs. The experience gained in the initial phase of the implementation is of immense value, to be utilised not only to make mid-course corrections but also to make long-term policies and guidelines after a comprehensive review of the effectiveness of DM plans undertaken in the short term.

9.1.5 All coastal states and UTs will develop their DM plans through an extensive consultative approach covering all stakeholders and in conjunction with their district-level plans.

9.1.6 The guidelines provide for strengthening cyclone DM in the country on a sustainable basis. These guidelines have set modest goals and objectives to be achieved by mobilising all stakeholders through an inclusive and participative approach. Appropriate allocation of financial and other resources, including dedicated manpower and

targeted capacity development, would be the key to the success of implementing the guidelines.

## 9.2 Implementing the Guidelines

9.2.1 Implementing the guidelines at the national level would begin with preparing the National Plan. The plan will spell out detailed work areas, activities and agencies responsible, and indicate targets and time-frames. The plan thus prepared will also specify indicators of progress to enable their monitoring and review. The National Plan will be prepared by NEC, based on the guidelines, and implemented with the approval of NDMA.

### 9.2.2 The ministries/agencies concerned, in turn, will:

- i) Provide guidance on the implementation of the plans to all stakeholders,
- ii) Obtain periodic reports from the stakeholders on the progress of implementation of DM plans,
- iii) Evaluate the progress of implementation of the plans against the time-frames and take corrective measures wherever needed,
- iv) Disseminate the status of progress and issue further guidance on implementation of the plans to stakeholders, and
- v) Report the progress of implementation of the National Plan to NDMA/NEC.

9.2.3 MoES will keep NDMA/NEC apprised of the progress of implementation of their modernisation plan related to improvement of the cyclone warning system on a regular basis.

9.2.4 SDMAs/SECs will develop state/UT-level DM plans on the basis of these guidelines. SDMAs will approve these and keep NDMA informed. The state departments/authorities concerned will implement and review the execution of DM plans at the district and local-levels along the above lines.

## 9.3 Implementation and Coordination at the National Level

9.3.1 Planning, implementing, monitoring and evaluating are four facets of the comprehensive implementation of DM plans. NEC or the concerned ministries/departments will identify appropriate agencies, institutions and specialists with expertise in relevant fields, and involve them in various activities to help implement cyclone DM plans, in accordance with the spirit of the national guidelines, and keep NDMA periodically posted.

9.3.2 Separate groups of individuals or agencies will undertake each of the above-mentioned four sets of activities. Some individuals may be common to the first three groups. However, the fourth group involved in evaluating the outcome of planning, executing and monitoring, needs to consist of specialists who are not directly involved in any of first three groups. This will help in getting an objective feedback on the effectiveness of the implementation of these guidelines. The availability of professional expertise is, therefore, crucial for monitoring and successfully implementing the cyclone DM plan, and will be built-up at all levels.

9.3.3 The cyclone DM framework also imposes additional responsibility on professionals to improve their skills and expertise corresponding to best practices the world over and to contribute to capacity development, as well as cooperate with and form partnership with other stakeholders. Synergy among their activities can be achieved by developing detailed documents on how to implement each of the activities envisaged in these guidelines.

9.3.4 Procedures need to be developed to elaborate the monitoring mechanism to be employed for undertaking transparent, objective and independent review of activities outlined in these guidelines. This process can be smooth and successful if a single window system is adopted for the conduct and documentation of each of the

above four phases. Each of the stakeholder ministries, departments, government agencies and organisations will designate a nodal officer to facilitate this.

#### 9.4 Institutional Mechanism and Coordination at State and District Levels

9.4.1 On the lines of the measures indicated at the national level, SDMAs and DDMAAs will also identify appropriate agencies, institutions and specialists with experience in relevant fields and involve them in various activities to help implement the cyclone DM plans. Likewise, measures indicated at the national level, such as designating a nodal officer in each line department, will achieve similar objectives.

9.4.2 The state will allocate and provide necessary finances for efficient implementation of these plans. Similarly, district and local level plans will be developed and the need to follow a professional approach will be reinforced. SDMAs will work-out, along with the various stakeholders, suitable mechanisms for the active involvement of associations of professional experts for planning, implementing and monitoring DM initiatives. These activities are to be taken up in a project mode with a specifically earmarked budget (both plan and non-plan) with each activity and to be implemented in a fixed time-frame.

9.4.3 The approach followed will emphasise on comprehensive cyclone safety and risk reduction measures, including structural and non-structural preparedness measures. They will be environment and technology-friendly, sensitive to the special requirements of vulnerable groups and address all stakeholders involved in cyclone DM. This will be achieved through strict compliance with existing and new policies.

9.4.4 As brought-out in section 7.15 of this document, there is a need to define the role of DM

Departments in states/UTs and adequately strengthen them for putting them at the centre-stage of all DM related activities. It is also essential that officers handling DM subjects have security of tenure, in order to get the best out of their experience, and to do justice to the office they are holding and responsibilities they are to discharge.

#### 9.5. Financial Arrangements for Implementation

9.5.1 For too long, DM in India was marginalised as an issue of providing relief and rehabilitation to the people affected by natural calamities. The new vision of GoI is a paradigm shift in the approach to DM: from the erstwhile relief-and-response-centric approach to a holistic and integrated approach—which will also be a pro-active prevention, mitigation and preparedness driven approach. These efforts will conserve developmental gains, besides minimising loss to lives, livelihood and property. This would, therefore, be the underlying principle for the allocation of adequate funds at all levels for prevention, mitigation and preparedness, along with strengthening the relief and rehabilitation machinery.

9.5.2. The return on investment on mitigation measures is very high. According to WMO, US \$1 invested in disaster mitigation can prevent about US \$7-worth of disaster related economic losses. It is also usually said that 'you pay something for doing' and 'pay much more for not doing'. Thus, financial strategies will be worked out in such a way that necessary funds are in place and their flow for implementing the cyclone DM plan is organised on a priority basis.

9.5.3 The sources of funding for all cyclone DM plan related activities will be as follows:

- (i) Annual Plan/Budget: for mainstreaming cyclone DM plans into developmental plans of respective ministries/departments at the centre and state governments/UTs.

- (ii) Centrally Sponsored/Central Sector Schemes.
- (iii) National Mitigation Projects by NDMA and other specific projects either by the central government or state governments; funded internally/externally.
- (iv) Public-Private Partnership.

9.5.4 New development projects, including SEZs, ports, etc., can also affect the vulnerability profile of coastal areas. Therefore, the DM departments in coastal states/UTs will ensure that new development projects would comply with the requisite cyclone resistant design and construction practices.

9.5.5 The approval and disbursement of funds from multilateral agencies and other financial institutions to such developmental initiatives will be linked to their compliance with these norms in accordance with the rules of GoI. The Department of Economic Affairs, Ministry of Finance, GoI, will ensure this. Interfacing of the techno-legal and financial measures will improve the safety aspects of coastal investments.

## 9.6 Implementation Model

9.6.1 These guidelines will come into force with immediate effect. The implementation model will

cover actions in two phases. The phase-I action covering 0 to 2 years from 2008 to 2010 and phase-II actions covering 0 to 4 years from 2008 to 2012. The DM plan will indicate detailed work areas and activities/targets with suggested time-frames and suitable indicators of progress along with the authorities/stakeholders responsible for implementing the guidelines. Different milestones and appropriate monitoring mechanisms will also be indicated.

9.6.2 The activities in Phase I will pose very serious challenges as they will lay the foundation for cyclone risk minimisation with adequate protection to coastal zones and the safety of vulnerable coastal communities. In the subsequent phases, the activities will be further intensified and special efforts will be made to consolidate the lessons of Phase I in mobilising more effective participation of stakeholders for achieving cyclone risk reduction.

9.6.3 Major action points are listed at the end of each chapter along with references to the sections under which they have been discussed. Implementing agencies and time-frames of implementation have been indicated. Some actionable points are also mentioned in boxes. They will also be taken into consideration while preparing and executing DM plans on a priority basis.

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