सत्यमेव जयते

NATIONAL DISASTER MANAGEMENT GUIDELINES

Management of Tsunamis

August 2010

NATIONAL DISASTER MANAGEMENT AUTHORITY
GOVERNMENT OF INDIA

National Disaster Management Guidelines

Management of Tsunamis

National Disaster Management Guidelines: Management of Tsunamis

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National Disaster Management Guidelines: Management of Tsunamis has been formulated under the Chairmanship of Prof. N. Vinod Chandra Menon, Hon'ble Member, NDMA in consultation with various stakeholders, academic experts and specialists in the concerned subject and officials from the Ministries and Departments of Government of India and State Governments.

National Disaster Management Guidelines

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National Disaster Management Authority
Government of India

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Vice Chairman
National Disaster Management Authority
Government of India

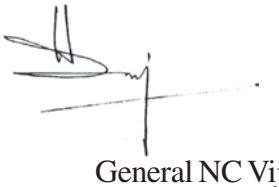
FOREWORD

As envisaged in the Disaster Management Act 2005, the National Disaster Management Authority (NDMA) since its inception has been prioritizing the critical areas for improving the effectiveness of disaster management in the Country. Among the major categories of natural disasters for which NDMA was working on was the preparation of National Disaster Management Guidelines on Tsunami. This posed enormous challenges, especially since the Indian Ocean Tsunami of 26th December 2004 exposed the systemic weaknesses in the understanding on the Tsunami risks and vulnerabilities in the Indian Ocean region. In the past three years, NDMA had convened a National Conference, a National Workshop and several meetings of the Core Groups of experts on various aspects of the management of Tsunamis. These Guidelines are the outcome of all these deliberations.

I hope that the various stakeholder groups involved in the management of Tsunami will benefit from these Guidelines and contribute further in the preparation of Tsunami management plans at the national level and follow up actions at the national, state and local levels. I am sure that these Guidelines will contribute immensely in improving the Tsunami preparedness, mitigation and emergency response not only in the coastal districts of the Country, but also provide the necessary support for consolidating the capacity building, training, education, and research and development by professionals in leading national institutions in the Country.

I have great pleasure in expressing my appreciation of the contribution by members of the Core Group, Extended Group and the participants of the National Conference and Workshops on the management of Tsunami. The efforts of Prof. N. Vinod Chandra Menon, Member, NDMA in guiding and coordinating these Core Group meetings, Extended Group meetings, Conferences and Workshops are highly appreciated. I must also place on record our appreciation for the

contribution made by all other Members of the NDMA during several review meetings of the Gudielines in the NDMA.



New Delhi
22nd July 2010

General NC Vij
PVSM, UYSM, AVSM (Retd)

सत्यमेव जयते

Member
National Disaster Management Authority
Government of India

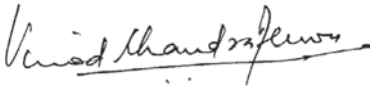
ACKNOWLEDGEMENTS

The preparation of the National Disaster Management Guidelines for the Management of Tsunamis has been a very challenging process over the past more than three years. The decision by NDMA to initiate the process of preparation of Guidelines on Management of Tsunamis was followed by a series of interactions with professional experts from various stakeholder groups through a series of Conferences, Workshops and Core Group meetings. As experienced during the immediate aftermath of the Indian Ocean Tsunami of 26th January 2004, the process of identification of critical gaps and systemic weaknesses in the management of tsunamis in India turned out to be a formidable challenge as several divergent views by various stakeholders had to be reconciled with an understanding of the lack of preparedness, mitigation and response strategies stemming out essentially due to lack of awareness on tsunami risk and vulnerability in the coastal districts of India.

I am extremely grateful to the specialists and experts who agreed to become the members of the Core Groups, Extended Groups and to the participants in the National Conference, National Workshop and the series of meetings held over the past three years in addressing the concerns related to the management of tsunamis in India. At NDMA, I am extremely grateful to Gen N C Vij, PVSM UYSM AVSM (Retd), Vice Chairman, NDMA and other distinguished Members of NDMA who painstakingly went through several versions of these Guidelines and suggested significant recommendations to improve the Guidelines.

I am grateful to the eminent administrators in the various Ministries and Departments of Government of India and State governments and the scientists and technocrats in several academic and professional institutions and agencies for contributing to these Guidelines. I must acknowledge the insights of Dr. P. S. Goel, Former Secretary, Ministry of Earth Sciences and his successor Dr. Shailesh Naik for establishing and commissioning the Tsunami Early Warning System as a very

sophisticated advanced network with several institutions. I am also grateful to Shri Sampurnananda Mahapatra, Senior Specialist (Earthquake and Tsunami) at NDMA, Shri K. Vijaya Kumaran, Shri Suresh K.B., Shri P.K. Datta, Ms. Jyoti, Shri Sunny Loyal, Shri M.P. Thomas Kutty, Shri Rajesh Jha and Shri Ravinder Rai in my Secretariate and other officers and staff of NDMA for their whole-hearted support in finalizing these Guidelines. Shri Sampurnananda Mahapatra's sincere contributions in the preparation of these Guidelines is specially appreciated.



New Delhi
22nd July 2010

N. Vinod Chandra Menon
Member, NDMA

Abbreviations

AICTE	:	All India Council for Technical Education
ALTM	:	Airborne Laser Terrain Mapping
APC	:	Areas of Particular Concern
ARMVs	:	Accident Relief Medical Vans
ATI	:	Administrative Training Institute
BAI	:	Builders Association of India
BIS	:	Bureau of Indian Standards
BMTPC	:	Building Material Technology Promotion Council
BPR	:	Bottom Pressure Recorders
BPS	:	Bottom Pressure Sensors
CBOs	:	Community Based Organizations
CBRI	:	Central Building Research Institute
CBSE	:	Central Board of Secondary Education
CDRN	:	Corporate Disaster Resource Network
CIDC	:	Construction Industry Development Council
CESS	:	Centre for Earth Science Studies
CFI	:	Construction Federation of India
CMT	:	Centroid Moment Tensor
CMZ	:	Coastal Management Zone
CoA	:	Council of Architecture
CoS	:	Committee of Secretaries
CRZ	:	Coastal Regulation Zone
CRS	:	Central Receiving Stations
CSC	:	Common Service Centres
CSIR	:	Council of Scientific and Industrial Research
CSR	:	Corporate Social Responsibility
CWC	:	Central Water Commission
CWPRS	:	Central Water and Power Research Station
DART	:	Deep Ocean Assessment & Reporting System (DART) in Indian TWS
DBCP	:	Data Buoy Cooperation Panel
DCR	:	Development Control Regulations
DDMA	:	District Disaster Management Authority

DEM	:	Digital Elevation Model
DEOCs	:	District Emergency Operations Centres
DM	:	Disaster Management
DNA	:	Deoxyribo Nucleic Acid
DoS	:	Department of Space
DRR	:	Disaster Risk Reduction
DRM	:	Disaster Risk Management
DRN	:	Disaster Response Network
DST	:	Department of Science & Technology
DVA	:	Detailed Vulnerability Assessment
EEZ	:	Exclusive Economic Zone
EPA	:	Environment (Protection) Act, 1986
EGAS	:	Ecologically and Geomorphologically Important Areas
ENC	:	Electronic Navigational Chart
EOC	:	Emergency Operations Centre
FTP	:	File Transfer Protocol
GDC	:	Geospatial Data Centre
GIS	:	Geographic Information System
GOES	:	Geostationary Operational Environmental Satellite
GoI	:	Government of India
GSI	:	Geological Survey of India
GTS	:	Ground Tracking Station
HCR	:	High Corrosion Resistant
HHZ	:	High Hazard Zone
HSC	:	Hazard Safety Cell
HTL	:	High Tide Line
ICAR	:	Indian Council of Agricultural Research
ICG/ITSU	:	International Coordination Group for the Tsunami Warning System in the Pacific
ICG/IOTWS	:	Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning System
ICMAM	:	Integrated Coastal and Marine Area Management
ICZMP	:	Integrated Coastal Zone Management Project
IDRN	:	India Disaster Resource Network
IE(I)	:	Institution of Engineers (India)
IHO	:	International Hydrographic Office

IIT	:	Indian Institute of Technology
IMD	:	India Meteorological Department
INCOIS	:	Indian National Centre for Ocean Information Services
INHD		Indian Naval Hydrographic Department
IOC	:	Intergovernmental Oceanographic Commission
IRC	:	Indian Road Congress
IRS	:	Incident Response System
IRTs	:	Incident Response Teams
ISDN	:	Integrated Services Digital Network
ITI	:	Industrial Training Institute
IWO	:	Initial Withdrawal of the Oceans
JFM	:	Joint Forest Management
LHZ	:	Low Hazard Zone
LTL	:	Low Tide Line
LIDAR	:	Light Detection and Ranging
MCI	:	Medical Council of India
MCIT	:	Ministry of Communication and Information Technology
MEA	:	Ministry of External Affairs
MEOCs	:	Mobile Emergency Operations Centres
MFRs	:	Medical First Responders
MHA	:	Ministry of Home Affairs
MoCI	:	Ministry of Commerce and Industries
MoD	:	Ministry of Defence
MoE&F	:	Ministry of Environment & Forest
MoES	:	Ministry of Earth Sciences
MoF	:	Ministry of Finance
MoHRD	:	Ministry of Human Resource Development
MoHUPA	:	Ministry of Housing and Urban Poverty Alleviation
MoIB	:	Ministry of Information and Broadcasting
MOST	:	Method of Splitting Tsunami
MoRD	:	Ministry of Rural Development
MoUD	:	Ministry of Urban Development
MoPR	:	Ministry of Panchayati Raj
NAP	:	National Afforestation Programme
NAC	:	National Academy of Construction
NATMO	:	National Atlas and Thematic Mapping Organization

NBCC	:	National Building Construction Corporation Ltd.
NCC	:	National Cadet Corps
NCMC	:	National Crisis Management Committee
NCRMP	:	National Cyclone Risk Mitigation Programme
NDEM	:	National Database for Emergency Management
NEC	:	National Executive Committee
NECP	:	National Emergency Communications Plan
NDMA	:	National Disaster Management Authority
NDRF	:	National Disaster Response Force
NEOC	:	National Emergency Operations Centre
NERMP	:	National earthquake Risk Mitigation Project
NEWC	:	National Early Warning Centre
NGO	:	Non Government Organization
NHO	:	National Hydrographic Office
NICMAR	:	National Institute of Construction Management and Research
NIDM	:	National Institute of Disaster Management
NIOT	:	National Institute of Ocean Technology
NIT	:	National Institute of Technology
NITTTR	:	National Institutes of Technical Teachers' Training and Research
NNRMS	:	National Natural Resources Management System
NPCBEERM	:	National Programme for Capacity Building of Engineers in Earthquake Risk Management
NPCBAERM	:	National Programme for Capacity Building of Architects in Earthquake Risk Management
NPDM	:	National Policy on Disaster Management
NPEEE	:	National Programme for Earthquake Engineering Education
NQRT	:	National Quick Response Team
NRSC	:	National Remote Sensing Centre
NSDI	:	National Spatial Data Infrastructure
NSS	:	National Service Scheme
NYKS	:	Nehru Yuva Kendra Sangathan
PC-NNRMS	:	Planning Committee of Natural Resource Management System
PMWS	:	Probable Maximum Wind Speed
PPP	:	Public Private Partnership
PSHA	:	Probabilistic Seismic Hazard Analysis
PTHA	:	Probabilistic Tsunami Hazard Analysis

PTWC	:	Pacific Tsunami Warning Centre
QIP	:	Quality Improvement Programme
QRMTs	:	Quick Reaction Medical Teams
RCC	:	Reinforced Cement Concrete
R&D	:	Research & Development
RTSMN	:	Real Time Seismic Monitoring Network
RVS	:	Rapid Visual Screening
SAC	:	Space Applications Centre
SDMA	:	State Disaster Management Authority
SDRF	:	State Disaster Response Force
SEMCs		State Earthquake Management Committees
SERC	:	Structural Engineering Research Centre
SEOCs	:	State Emergency Operations Centres
SEZ	:	Special Economic Zone
SMS	:	Short Message Service
SoI	:	Survey of India
SOPs	:	Standard Operating Procedures
SRC	:	State Relief Commissioner
TEWS	:	Tsunami Early Warning System
THZ	:	Tsunami Hazard Zone
TMT	:	Thermo Mechanically Treated
TWS	:	Tsunami Warning System
UAV	:	Unmanned Aerial Vehicle
UEVRP	:	Urban Earthquake Vulnerability Reduction Programme
UGC	:	University Grants Commission
ULBs	:	Urban Local Bodies
UNDP	:	United Nations Development Programme
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UT	:	Union Territory
VSAT	:	Very Small Aperture Terminal
VSS	:	Vana Samrakshana Samitis
WMO	:	World Meteorological Organization

Glossary of Terms

Arrival Time

Time of arrival of the first wave of a tsunami at a particular location.

Bathymetry

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

Carbon Sequestration

A geo-engineering technique for the long-term storage of carbon dioxide or other forms of carbon, for the mitigation of global warming using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks.

Coastal Area

The area of land behind the sea coast up to the zero inundation line during the estimated future tsunamis and beyond the coast in the sea requiring tsunami management; the area on the landward side of the mean water line and the area up to 5m. water depth on the seaward side of the mean water line.

Crest Length

The length of a wave along its crest, sometimes also called crest width.

Estimated Time of Arrival

Computed arrival time of the first wave of a tsunami at the coast after the occurrence of specific major disturbance in the ocean like earthquakes, landslides, volcanic activity in the ocean, meteorite impact on the ocean surface etc.

Estuaries

Long narrow interlaced water bodies associated with the coast, experiencing tidal exchange, including portions of the rivers joining the sea.

Elapsed Time

Time interval between observed time of arrival of the first wave of a tsunami at a specific location on the coast and the time of returning to the normal water level conditions.

Evacuation Map

A drawing or representation that outlines danger zones and designates limits beyond which people must be evacuated to avoid any harm from tsunami waves.

Far field Tsunami

A tsunami capable of widespread destruction, not only in the immediate region of its generation, but across the entire ocean basin.

Green's Function

A type of function used to solve inhomogeneous differential equations subject to boundary conditions.

Inundation Distance

The distance that a tsunami wave penetrates onto the shore, measured horizontally from the mean water line.

Intensity

Intensity is the degree of damage caused by a tsunami.

Local Tsunami or Near- field Tsunami

A tsunami which has destructive effects (confined to coasts within 200 Kms of the Source with arrival time less than 30 minutes).

Maximum Run up

Maximum Run up (Amplification) is the difference between the elevation of maximum tsunami and the elevation of the mean water level.

Maximum Water Level

Maximum water level is the difference between the elevation of the highest local water mark and the elevation of the shoreline at the time of the tsunami outbreak.

Mean Tsunami Height

Average height of a tsunami measured from the trough to the crest.

Mean Sea Level

The average height of sea surface, based upon hourly observation of tide height on the open coast or in adjacent waters which have free access to the sea.

Near-Field Tsunami

A tsunami from a nearby source, generally less than 200 km or associated with a short travel time of less than 30minutes.

Paleo tsunamis

Previous tsunamis determined from the study of the coastal sedimentary columns, using geological techniques. Recurrence rate of tsunamis can be deduced from these studies.

Regional Tsunami

A tsunami capable of destruction in a particular geographic region, generally within about1000 km of its source. Regional tsunamis also occasionally have very limited and localized effects outside the region.

Run up level

Run up level is defined as maximum elevation in land up to which it is inundated by sea water during a Tsunami.

Travel Time

Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Tsunami

A Japanese term meaning "harbour wave", derived from the characters "tsu" meaning harbour and "nami" meaning wave, to describe a system of ocean gravity waves having a long wave length and period (time between crests), formed as a result of large-scale disturbance of the sea caused by an earthquake.

Tsunami Damage

Loss or damage directly or indirectly caused by a destructive tsunami, including loss of lives, damage to assets, property and infrastructure as well as disruption of livelihoods of affected communities.

Tsunami Dispersion

Redistribution of tsunami energy, particularly as a function of its period, as it travels across a body of water.

Tsunami Height

The vertical distance between the crest (highest point over the water surface) and trough (lowest point over the water surface) of a tsunami.

Tsunami Magnitude

A number characterizing the strength of a tsunami based on the tsunami wave height.

Tsunami Period

Time that a tsunami wave takes to complete a cycle. Tsunami period typically ranges from 5 minutes to two hours.

Tsunami Vulnerability Assessment

The tsunami vulnerability assessment is expressed as details of elements of the built, natural and human environments vulnerable to potential tsunami-related damage.

Tsunami Wavelength

Horizontal distance between successive crests of a tsunami wave.

Tsunami Wave-current

Water particles move in a circular or elliptical motion in a horizontal plane in wind driven waves, only up to certain water depth from water surface, where as Tsunami waves generate a current velocity in water which is prevalent throughout the depth of water from seabed to the top surface.

Vulnerability Line

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.

VSAT

Very Small Aperture Terminal (VSAT) is a two-way satellite ground station with a dish antenna that is smaller than 3 meters, most commonly used to transmit narrowband or broadband data.

Executive Summary

Background

The Indian Ocean Tsunami of 26th December 2004 which devastated the coastal communities in Kerala, Tamil Nadu, Andhra Pradesh, Puducherry and Andaman & Nicobar Islands prompted the Government of India (GoI) to take the pioneering step to establish appropriate institutional mechanisms for the effective management of disasters in India. As mandated by the Disaster Management Act 2005 (DM Act 2005), GoI created a multi-tiered institutional system with the National Disaster Management Authority (NDMA) as the apex body for disaster management in India, chaired by the Prime Minister of India, the State Disaster Management Authorities (SDMAs) chaired by the respective Chief Ministers and the District Disaster Management Authorities (DDMAs) chaired by the District Collectors and co-chaired by Chairpersons of the Zilla Parishads. These bodies have been set up to facilitate the paradigm shift from the hitherto relief-centric approach to a more proactive, holistic and integrated approach of strengthening disaster preparedness, mitigation and emergency response capacities in the country.

Soon after NDMA was set up, a series of consultations were initiated with various stakeholders for the preparation of National Disaster Management Guidelines for the effective management of tsunamis in India. Senior officials from Ministries and Departments of India and State Governments, academics, professionals, representatives of multi-lateral and national humanitarian agencies and corporate sector representatives participated in these meetings. While these meetings acknowledged that several initiatives taken up by various government agencies in the recent past had been significant and far-reaching, they also highlighted the need for evolving a holistic and integrated strategy for the effective management of tsunamis in India. A few Core Groups of specialists were set up to address the critical areas of concern identified through these deliberations and to recommend the strategies for improving the preparedness, mitigation and emergency response capacities in the tsunami-prone areas. On the basis of these deliberations, the Guidelines for the Management of Tsunamis (hereinafter referred to as the Guidelines) has been prepared by NDMA with the support of experts to assist concerned Ministries and Departments of GoI and State Governments to strengthen the tsunami preparedness, improve the tsunami mitigation efforts and enhance the emergency response capacities of stakeholder groups as well as to assist the concerned Ministries and Departments of the GoI and State Governments to prepare their DM plans.

Tsunami Risk and Vulnerability in India

The Indian Ocean Tsunami on 26th December, 2004 which devastated the coastal communities in 14 countries, caused enormous loss of life and damage to property, assets and

infrastructure in the coastal villages of Kerala, Tamil Nadu, Andhra Pradesh, Puducherry and the Andaman & Nicobar Islands. The tsunami risk and vulnerability which the coastal communities in India are exposed to, even by a distant high intensity earthquake in Indonesia, came as a shock and surprise to the unsuspecting public. The absence of an effective Tsunami Early Warning System (TEWS) and the last mile connectivity to disseminate alert and early warning messages to the coastal communities as well as the lack of public awareness and emergency response preparedness among the various stakeholder groups made the tsunami response more difficult and challenging.

Most Tsunamis are caused by earthquakes (of magnitude more than 6.5 on the Richter Scale), with a vertical disruption of the water column generally caused by a vertical tectonic displacement of the sea bottom along a zone of fracture in the earth's crust which underlies or borders the ocean floor. Tsunamis are also generated by volcanic eruptions and submarine landslides, nuclear explosions, and even due to impact or fall of large size meteorites, asteroids, and comets from outer space. Tsunamigenic zones that threaten the Indian Coast have been identified by considering the historical tsunamis, earthquakes, their magnitudes, location of the area relative to a fault, and also by tsunami modelling. Both the east and west coasts of India and the island regions are likely to be affected by tsunamis from the five potential source regions, viz., the Andaman-Nicobar-Sumatra island arc, Indo-Burmese zone, Nascent Boundary (in the central Indian Ocean), Chagos archipelago and the Makran subduction zone.

The Genesis of National Disaster Management Guidelines for Management of Tsunamis

The DM Act 2005 envisaged a paradigm shift in the GoI's focus from its hitherto post-disaster rescue, relief and rehabilitation-centric approach to a more proactive pre-disaster preparedness, mitigation and improved response capacities approach. This paradigm shift is also influenced by global best practices which have established that strengthening preparedness and mitigation strategies would considerably reduce the vulnerability of disaster-prone communities and thereby reduce the risks associated with tsunamis in the coastal areas.

These Guidelines have been prepared in recognition of the fact that even though tsunami is a low probability event, it is capable of resulting in enormous loss of lives, loss of property, assets and public infrastructure in the coastal areas. The main stakeholders in the tsunami risk management are the Ministry of Earth Sciences (MoES) and the Department of Science and Technology (DST) and its scientific and technical institutions like Indian Meteorological Department (IMD), Indian National Centre for Ocean Information Services (INCOIS), National Institute for Ocean Technology (NIOT), Integrated Coastal Area and Marine Management Directorate (ICMAM), Centre for Earth Science Studies (CESS), etc. involved in establishing and operating India's Tsunami Early Warning System (TEWS), tsunami modelling, paleo-tsunami studies, and coastal zone land use planning. Other major stakeholders involved in coastal zone land use planning, vulnerability reduction, immediate response, rescue and recovery include the

Ministry of Environment & Forests (MoEF), Ministry of Urban Development (MoUD), Ministry of Housing and Urban Poverty Alleviation (MoHUPA), Ministry of Information and Broadcasting (MoIB), Ministry of Panchayati Raj (MoPR), Ministry of Rural Development (MoRD); State Governments and Union Territory (UTs) Administrations along the coast and the islands; coastal development authorities, coastal municipalities and panchayati raj institutions, Indian Navy, the Coast Guards, NGOs and the corporate sector.

As a first step, a meeting of the stakeholders including the officials from concerned Ministries and Departments, representatives from R&D institutions, mapping organizations, academic & technical institutions, and professionals from scientific and technical institutions was convened in New Delhi on 18th May 2007, with a view to pool the knowledge, identify the critical gaps in the effective management of tsunamis. Four thematic core groups were established by NDMA to address the critical gaps and suggest strategies for effective management of tsunamis in India. Several meetings of the core groups were subsequently held and a set of draft guidelines was evolved for addressing the identified critical gaps. The draft guidelines were presented before the enlarged group of scientific and technical institutions, academic and research institutions, Ministries and Departments of GoI and State Governments/UT Administrations, representatives of corporate and NGO sectors, the Indian Navy and other stakeholders in a National Workshop on 29th November, 2007. The revised Guidelines were presented before an extended group of experts and specialists and a general consensus was evolved on the strategies to be pursued for addressing the tsunami risk and vulnerability and for improving the effectiveness of tsunami preparedness, mitigation and emergency response. The recommendations and action points that emerged out of the core group discussions and Workshop deliberations with the extended group of experts have resulted in the finalisation of these Guidelines. Several rounds of discussions with the Vice Chairman and Members of NDMA contributed substantially in ensuring that the Guidelines address the critical gaps and offers comprehensive strategies for strengthening the preparedness, mitigation and emergency response capacities in tsunami-prone areas.

Structure of the Guidelines

Adequate preparedness and mitigation measures from tsunami hazard need to be put in place to save the lives, property and livelihoods of those living in the coastal areas. The Guidelines include a wide range of approaches for strengthening the tsunami preparedness and mitigation, including tsunami warning systems, capacity building, education, building codes and safety standards, land use planning, and other engineering solutions.These Guidelines are an important step towards comprehensive tsunami risk management in India, by developing resilience to face future tsunamis and for integrating risk mitigation measures as a part of routine safety culture. These Guidelines have been prepared to provide direction to all stakeholders and appropriate guidance to Ministries and Departments of the GoI and state authorities for the preparation of their detailed Disaster Management (DM) Plans as stipulated in the DM Act, 2005.These Guidelines call for a proactive, participatory, well structured, fail-safe, multi-disciplinary and multi-

sectoral approach for improved preparedness, mitigation and emergency response at various levels.

The Guidelines are presented in 8 chapters as detailed below:

Chapter 1 provides an introductory overview that reflects the tsunami risk and vulnerability in the country, identifies the critical areas of concern, and provides a description of past initiatives for addressing coastal hazards, and outlines the post tsunami initiatives and the roadmap for a comprehensive approach to tsunami risk management in India.

Chapter 2 on Tsunami Risk and Vulnerability Assessment provides a brief overview of various approaches to understand the tsunami hazard, risk and vulnerability assessment in the context of our coastal areas, based on global best practices in tsunami-prone countries.

Chapter 3 on Tsunami Preparedness provides the highlights of India's state of the art Tsunami Early Warning System for the issue of alert and early warning messages and describes the mechanisms proposed for the dissemination of such messages to the coastal communities. It also outlines the strategies for strengthening public awareness on tsunami risk and vulnerability as well as various aspects of tsunami risk management preparedness measures by various stakeholder groups. This Chapter also provides a roadmap for improving the capacity development of stakeholder groups including education, training, R&D and documentation.

Chapter 4 on Structural Mitigation Measures provides guidance on design and construction of new structures as well as on strategies for protecting lifeline and priority structures along the sea front.

Chapter 5 on Techno-Legal Regime provides guidance on the techno-legal and techno-financial regime for tsunami risk reduction.

In Chapter 6 on Emergency Response, a robust mechanism has been proposed for strengthening the post- tsunami response capacities of stakeholder groups.

Chapter 7 on Ensuring Implementation provides guidance for preparing disaster management plans at various levels.

Chapter 8 provides a Summary of Action Points.

Apart from the above Chapters, the Guidelines also provide Annexures on a few important aspects of tsunami risk management, including a brief overview of various toolkits for tsunami risk management.

Nodal Agency

The MoES as the Nodal Ministry, in close co-operation with MoEF, DST and other concerned agencies, will prepare a detailed Action Plan in accordance with these Guidelines with specific tasks, activity targets and time-frames as a Tsunami Management Plan, which will also contribute to the National DM Plan.

1 The Context

1.1 Overview

1.1.1 Even though most people were not aware of the tsunami risk in India's coastal states, the Indian Ocean Tsunami of 26th December 2004 exposed the inherent vulnerabilities of the coastal communities in our 7516 km long coastline. The coastal population has been increasing steadily, mostly due to the expanding scope for exploitation of sea resources and economic activities propelled by increasing urbanization and industrialization in the coastal districts as well as increasing employment opportunities due to the unprecedented expansion in tourism-related activities. However, so far the efforts to strengthen the preparedness of the coastal communities to face the increasing threats of storm surges, sea level rise, coastal erosion, etc. have been often restricted to localized campaigns with very limited impact, in spite of the increasing disaster risk and vulnerability of the coastal communities.

1.2 Tsunami in the Indian Sub-continent

1.2.1 In the past, a few devastating tsunamis have occurred in the Indian Ocean and in the Mediterranean Sea. The most significant tsunami in the region of the Indian Ocean was the one associated with the violent explosion of the volcanic island of Krakatoa in August 1883 which reportedly triggered a thirty metre high tsunami wave and killed 36,500 people in Java and Sumatra in Indonesia.

1.2.2 Although not as frequent as in the Pacific Ocean, tsunamis generated in the Indian Ocean pose a great threat to all the countries of the region. Countries most vulnerable to tsunamis in the Indian Ocean region are: Indonesia, Thailand, India, Sri Lanka, Pakistan, Iran, Malaysia, Myanmar, Maldives, Somalia, Bangladesh, Kenya, Madagascar, Mauritius, Oman, Reunion Island (France), Seychelles, South Africa and Australia. Even though tsunamis occur very rarely in the Indian Ocean region, in the last 300 years, this region recorded 13 tsunamis and 3 of them occurred in the Andaman and Nicobar region for which the details of location of epicenter, death/ damage caused etc. are not known. The three tsunamis which affected Andaman and Nicobar islands occurred on 19th August 1868, 31st December 1881 and 26th June 1941. The 1945 tsunami following an earthquake of magnitude 8.2 Ms in the Arabian Sea had a maximum run up of 13 metres in Pakistan and resulted in the death of 4,000 people. Overall, the run-up levels in the Indian Ocean tsunamis varied from 1 to 13 metres. In 1977, a strong earthquake of magnitude Ms 8.1 struck west of Sumba Island in Indonesia, but there were no reports of casualties in India due to this tsunami.

1.3 Indian Ocean Tsunami of 26th December 2004

1.3.1 The Indian Ocean Tsunami of 26th December 2004 is one of the most destructive Tsunamis known to have hit India and 13 other countries in the Indian Ocean region. With a combined toll of 238,000 casualties (including 51,500 people missing), and roughly more than 1.5 million people displaced in fourteen countries, this tsunami resulted in damage and destruction of property, assets and infrastructure in the coastal areas. In India 10,749 people lost their lives due to the tsunami and 5,640 people were missing in the Tsunami-affected areas.

1.4 Lessons Learnt and Analysis of Critical Gaps

1.4.1 One of the major gaps in the Tsunami risk management was the lack of awareness on the tsunami risk and vulnerability in India, and hence the lack of preparedness as reflected in the absence of a Tsunami Early Warning System (TEWS) in India. After the 2004 Indian Ocean Tsunami, India has now developed a state-of-the-art Tsunami Early Warning System in the country. The critical gaps that now remain are the lack of public awareness on tsunami risk and vulnerability in the coastal areas, the weak enforcement and compliance of town planning byelaws, development control regulations and building codes in the coastal areas, and the challenges in implementation of appropriate technologies to disseminate and communicate the early warning to the coastal inhabitants located in the near vicinity of a near source tsunami.

1.4.2 When a large subduction zone earthquake occurs nearby, the first tsunami waves may reach coastal communities within minutes after the occurrence of the earthquake. This is especially true for the Andaman and Nicobar islands which lie close to the Java Sumatra subduction zone. Local populations at risk must be able to recognize the signs of impending tsunami hazard such as strong, prolonged ground shaking, the receding of the shoreline, bubbles in the sea, change in colour of the sea, etc. and seek safety in higher ground immediately. The traditional and indigenous knowledge of coastal communities about patterns of tsunami behaviour like the receding of the shoreline by several metres before the onset of the tsunami will be documented and shared with tsunami-prone coastal communities.

1.4.3 Communities also need to know the areas likely to be inundated, possible evacuation areas, designated evacuation routes and safe regions to assemble evacuees and set up temporary relief camps in safe high ground in the coastal areas.

1.4.4 Planners, emergency responders, and residents in the coastal areas need to understand the multi-hazard ramifications of a very large local earthquake that will disrupt much of the community infrastructure. At-risk regions need near-real time determination of earthquake source information to assess the nature of the hazard in order to optimize emergency response. Local governance personnel need to understand the nature of the risk and should be familiar with the long term benefits of mitigation measures while making long-term planning decisions.

1.4.5 A sustained public awareness program will be initiated to gain the long-term support of coastal populations and to institutionalize tsunami mitigation in an all-hazard approach to risk reduction. Tsunami-resilient building codes need to be prepared and widely disseminated.

1.5 Past Initiatives with reference to Coastal Areas

1.5.1 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 construction activities along the coast up to 500 metres from the maximum high tide line. 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 carried out taking into account the coastal and marine environment, natural hazards, socio-economic problems and developmental activities. The CRZ Guidelines were prepared in consultation with the coastal states and UTs. The CRZ Guidelines also suggested that construction along the coast, irrespective of their location, i.e., even beyond 500 m of the high tide mark, should be subjected to environmental impact assessment studies. The CRZ Guidelines were circulated to all coastal states and UTs in March 1984. However, the required Environmental Management Plans as per the Guidelines are yet to be prepared by most of the coastal states and UTs.

1.5.2 The 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) within 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 the development activities going on in the coastal zones which have resulted in over-exploitation of marine and coastal resources and marked degradation of the quality of coastal habitats and environments, the CRZ notification was issued in February 1991.

1.5.3 The CRZ notification requires the states/UTs to prepare coastal zone regulatory management plans within a period of 3 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 these proposals, MoEF constituted different committees to review specific issues. Some of the committees constituted were: Fr. Saldanha Committee to review Ground water and sand mining issues in Lakshadweep and Andaman and Nicobar Islands; East coast road and issues related to the East Coast; B. B. Vohra Committee to examine the Relaxation for tourism projects; Balakrishnan Nair Committee to review the Issues relating to coastal areas of Kerala; the Sukthankar Committee to formulate a National Policy for Coastal Zone Management and Prof. M.S. Swaminathan Committee for reviewing the CRZ Notification 1991.

1.5.4 The Sukthankar Committee was the first to look into the National Coastal Zone Management Policy issues. The objectives of coastal zone management policy as envisaged by the Sukthankar Committee 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. Coastal areas were classified into four zones as given below:

a) Ecologically and Geomorphologically Important Areas (EGAS)

b) Areas of Particular Concern (APC)

c) 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 EGAS and APC; and

d) Low Hazard Zone (LHZ) : conservation zone

1.5.5 Based on the recommendations of various committees and requests made by different agencies, MoEF amended the CRZ Notification twelve times since August 1994 as per the provisions laid down in the EPA. Despite significant efforts by MoEF and the state governments, the CRZ guidelines were not fully implemented and continue to be so even today. In the context of CRZ provisions, the Indian Ocean tsunami of December 2004 along the Indian coast highlighted the following:

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

1.5.6 The buffer provided in the coastal zone and the approaches for conservation of mangroves, sand dunes, coral reefs and coastal forests were put to test during the tsunami and were found to be reasonably effective even in a calamity of this magnitude. This emphasises the need for creating an effective mechanism to incorporate coastal zone mitigation measures in development planning and coastal zone management practices. 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 M.S. Swaminathan Committee Report has further recommended that:

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

1.6 Issues for Priority Implementation and Integrated Coastal Zone Management (ICZM)

1.6.1 In the coastal districts, the government agencies have been addressing the issues related to regulation and effective management of coastal zones. The critical ongoing activities in the coastal areas such as dredging, sand mining, break water construction, construction of jetties, development of tourist resorts, etc. which have direct impact over the inter tidal area should also be reviewed as a part of coastal zone management.

1.6.2 In the late 1990s, the Supreme Court of India passed orders upholding the CRZ notification and directing the concerned authorities to prepare coastal zone management plans. Such plans were prepared by most states, but violations continue to occur. Under these circumstances, a fresh notification under EPA is being contemplated on the basis of the Supreme Court recommendation on Integrated Coastal Zone Management (ICZM), which is very comprehensive. However, issues beyond the recommendations of the Swaminathan Committee Report involve sustainability of coastal resources. A comprehensive resource management plan at the local scale, 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. A holistic approach to the sustainability of coastal resources and environment based on the existing and future local scale vulnerability profile which incorporates the concerns of climate change and sea level rise has to become a part of ICZM.

It is necessary to associate local panchayati raj institutions and local communities in the management of coastal resources for safeguarding human safety and ecological integrity in the coastal areas. Enhancing the economic well-being of the fishing and farming communities along the shoreline through an integrated bio-shield programme need to be assigned high priority. In the medium term, integrated and ecologically-socially sustainable coastal zone management systems should be put in place jointly by government agencies and coastal communities.

1.6.3 ICZM is a continuous and dynamic process that unites government and the community, experts in science, technology and management, and 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, integrate the concerns of all relevant sectors of society and of the economy. It is also important to recognise that coastal economic development is essential for improving the human development index of coastal population. This will have to be done by ensuring the biological diversity conservation and improving the productivity of coastal eco-systems. There is a need for continuous studies of ICZM plans for various sectors.

1.6.4 In the past decade, a number of coastal zone management projects have been taken up in various coastal districts. It is necessary to prepare ICZM plans based on the concept and premises of carrying capacity and ensure

community involvement at all stages of preparation of the plan. ICZM should therefore envisage optimum utilisation of coastal resources, minimisation of the impact of natural disasters and improvements 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 in a holistic manner. Together, they can achieve the goals and objectives of ICZM, which are:

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

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

(a) 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

(b) Land Environment: Delineation of a regional land environment management plan

(c) 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, delineation of regional biological environment management plans to include them in the conservation plans

(d) 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

(e) Noise Environment in Urban Areas: Delineation of an acoustic environment management plan in view of the aquatic fauna in the zone

(f) Socio-Economic Environment: Collection of baseline data on human settlements, demographic patterns, occupation, economic status, and health status of the community and compiling an inventory of existing facilities for social welfare and healthcare, including delineation of socio-economic historical and cultural status of the people.

1.7 National Initiatives

1.7.1 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 GoI constituted an Expert Committee under the

Chairmanship of Prof. M.S. Swaminathan on 19th July 2004. The Committee comprising experts from marine ecology, geology, sociology, law, coastal engineering, marine pollution, bio-diversity and remote sensing submitted its report on 14th February 2005. The MoEF has accepted the broad recommendations of the Report on 20th April 2005. The main recommendations are:

- Implementation of the ICZM Plan instead of a uniform regulatory approach.
- Allowing development along the coastal stretches based on the vulnerability/setback line.
- Inclusion of the ocean zone in the CRZ.
- Setting up of a National Institute for Sustainable Coastal Zone Management to address policy and legal issues.
- Addressing coastal water pollution in a time-bound manner.
- Identification, mapping and protection of the coastal eco-sensitive areas such as mangroves, corals, turtle breeding areas, etc. and,
- Developing bio-shields along the coastal stretches.

1.7.2 In order to implement the recommendations of the Prof. M.S. Swaminathan Committee Report, the 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 SoI, CESS, SAC and ICMAM 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 prepared, inviting public suggestions and objections as per EPA.

1.7.3 Based on the Prof. M.S. Swaminathan Committee Report, a draft Coastal Management Zone (CMZ) Notification, 2008 was issued. Large numbers of representations were received on the draft CMZ Notification, 2008. To review these comments, MoEF constituted another Committee under the Chairmanship of Prof. M. S. Swaminathan in June 2009. This Committee after examining the comments suggested that the CRZ Notification, 1991 be continued with some improvements to be incorporated in it. One of the improvements suggested was to incorporate hazard mapping exercise for the purpose of protecting the life and the property of local communities.

1.7.4 The methodology for demarcating the hazard line has been worked out in consultation with reputed national agencies like SoI, SAC, Department of Ocean Development, Chennai and CESS, Thiruvananthapuram. Further, to obtain international experience, Prof. John Pethick, Advisor to UK Government on coastal issues was engaged to recommend the methodology. Based on the methodology which was recommended, MoEF assigned SoI and SAC to delineate the hazard line on pilot scale in six areas of the coastline. The MoEF proposes to demarcate the hazard line in entire coastal areas of the mainland.

1.7.5 The hazard line for the mainland coast of India will be mapped and delineated as the landward composite of the coastal 100 year flood lines (which includes sea level rise impacts), and the 100 year predicted erosion lines. This will involve the following:

(i) surveys and preparation digital terrain model of 0.5m contour interval for the entire mainland coast;

(ii) collection of historical tide gauge data and analyses to determine 100 year flood levels;

(iii) analyses of maps and satellite imagery since 1967 to predict 100 year erosion line;

(iv) preparation of composite maps, showing the hazard line on the digital terrain model; and

(v) transfer of the hazard line to topographic maps for public dissemination. Once the hazard line is delineated, ground markers will be constructed. This is important as the revenue maps used for local planning purposes are not comparable to topographic maps.

1.7.6 Based on the recommendations of Prof. M. S. Swaminathan Committee, 2009, a pre-draft CRZ Notification 2010 has been issued and is available on the website of MoEF in nine local languages. Comments were sought by 30th May, 2010, and thereafter, the draft CRZ Notification, 2010 was issued under Environment (Protection) Act, 1986. In this pre-draft CRZ Notification 2010, the hazard line mapping has been incorporated in the coastal zone management planning. The newly proposed infrastructure would be located at safer locations keeping in view the hazard line. Precautions would be taken such as hard engineering and soft engineering for protecting the dwelling units of local communities living within the hazard line. However, new dwelling units would be located on the landward side of the hazard line.

1.7.7 The mapping of the hazard line is one of the components of the World Bank-assisted Integrated Coastal Zone Management Project (ICZMP) which has been approved by the GoI. As a part of this project, it is proposed to establish a National Centre for Sustainable Coastal Management at Chennai and initiate Pilot ICZM projects in Gujarat, Orissa and West Bengal.

1.8 Recent Major International Developments

1.8.1 The Intergovernmental Coordination Group for the Tsunami Warning and Mitigation System for the Indian Ocean (ICG/IOTWS) was established with the following objectives:

i) To coordinate the activities of the IOTWS;

ii) To organize and facilitate as appropriate the exchange of seismic, sea level and other data at or near real-time and information required for the interoperability of the IOTWS;

iii) To promote the sharing of experience and expertise related to tsunami warning and mitigation for the Indian Ocean basin;

iv) To promote tsunami research;

v) To promote the establishment and further development of national

tsunami warning and mitigation capacities in accordance with standard protocols and methods;

vi) To develop, adopt and monitor implementation of work plans of the IOTWS, and to identify required resources;

vii) To promote implementation of relevant capacity building;

viii) To liaise and coordinate with other tsunami warning systems;

ix) To liaise with other relevant organizations, programmes and projects;

x) To promote the implementation of the IOTWS within a multi-hazard framework; and

xi) To keep under constant scrutiny the status of the system and how it satisfies the needs.

1.8.2 The ICG/IOTWS has constituted 5 Working Groups from the Indian Ocean countries and observers from Intergovernmental Oceanographic Commission (IOC). The Working groups are as under:

Working Group 1: Seismic Measurements, Data Collection and Exchange

Working Group 2: Sea level data collection and exchange, including deep-ocean tsunami detection instruments

Working Group 3: Risk assessment

Working Group 4: Modelling, forecasting and scenario development

Working Group 5: Establishment of a system of interoperable advisory and warning centres

1.9 Critical Areas of Concern

1.9.1 Even though India's response to the Indian Ocean tsunami of 26th December 2004 showed the enormous strength of the administrative machinery in coordinating the response efforts at the national, state and district levels and the capacities of the civil society organisations in extending support to the tsunami-affected communities, the tsunami experience highlighted several critical areas which urgently needed attention. The GoI realized the need to strengthen the institutional mechanisms for improving the effectiveness of DM in India and set up appropriate authorities at the national, state and district levels. The Critical areas of concern, with respect to Tsunami Risk management, which require attention in India are the following:

- Lack of paleo-tsunami studies and a need for better understanding of past tsunami events for improved risk assessment ;
- Lack of high resolution near-shore bathymetric and topographic data will prove to be a limiting factor for inundation models ;
- Lack of easily accessible tsunami documentation ;
- Lack of documentation of traditional knowledge for tsunami risk management ;
- Inadequate community awareness on tsunami risk and vulnerability, and
- Lack of people's participation in strengthening disaster preparedness, mitigation and emergency response in the coastal areas.

2 Tsunami Risk Assessment and Vulnerability Analysis

2.1 The Context

2.1.1 It is important to collect historical tsunami data and on run-ups for better future estimate of tsunami hazard. The Indian National Centre for Ocean Information Services (INCOIS), Hyderabad has compiled databases of tsunamigenic earthquakes and carries out post-tsunami studies.

2.1.2 Prior to the Tsunami of 26 December 2004, the most destructive Pacific-wide Tsunami of recent history occurred along the coast of Chile on 22nd May 1960. All coastal towns between the 36th and 44th S (latitude) parallels either were destroyed or heavily damaged by the action of the waves and the quake. The combined Tsunami and earthquake toll included an estimated 2,000 people killed, 3,000 people injured, 2 million people rendered homeless and caused damages estimated at $550 million. Off Corral, the waves were estimated to be 20.4 meters (67 feet) high. The Tsunami caused 61 deaths in Hawaii, 20 in the Philippines, and 100 or more in Japan. Wave heights varied from slight oscillations in some areas to range of 12.2 meters (40 feet) at Pitcairn Islands, 10.7 meters (35 feet) at Hilo, Hawaii and 6.1 meters (20 feet) at several locations in Japan. Tsunamis are very common in the Pacific Ocean because it is surrounded on all sides by a seismically active belt. In the Hawaiian Islands, tsunamis approach from all directions, namely, from Japan, the Aleutian Islands and from South America.

2.2 The Tsunami Hazard and Its Assessment

2.2.1 Tsunamis are generated by large and rapid displacements of water, mainly from sudden and large scale changes in the configuration of the sea floor associated with fault displacement or gigantic underwater landslides, which could be mainly due to earthquakes.

2.2.2 Till the Indian Ocean tsunami hit the Indian shores on 26th December 2004, people were not aware about the possible tsunami threat in India. Only a few tsunami events in the past have occurred in the Indian Ocean and some of them were highly destructive causing inundation and flooding wiping out fishery business, disrupting tourism, polluting drinking water, damaging vegetation and crops, destroying shelters and damaging coastal navigation system making huge impact on the economy. It also caused widespread damage to jetties, harbours and coastal structures. Both East and West Indian shorelines are vulnerable to tsunami wave action. It has more than 2200 km shoreline which is heavily populated. For a tsunami to hit Indian coastline, it is necessary that a tsunamigenic earthquake of magnitude

greater than 6.5 should occur. Actual tsunami hazard of a coastline depends on its bathymetry and coastal topography.

2.2.3 Earthquakes generate tsunamis by vertical movement of the sea floor as in normal faulting or thrust faulting. If the sea floor movement is horizontal, tsunamis are not generated as in strike slip earthquake. However, it is equally possible that tsunamis are triggered also by marine landslides into or under the water surface. They can also be generated by volcanic activity and meteorite impacts, but such events are extremely rare. Tsunami hazard along a coastline is therefore a combination of all the potential sources of tsunamis that lie in the neighbouring sea or ocean. Tsunami velocity is dependent on the depth of water through which it travels, and is equal to the square root of depth times the gravitational acceleration. Tsunami waves travel at a speed of approximately 700 km/ hr in 4000 m of water. In 10 m of water the velocity drops to about 36 km/hr.

2.2.4 The Tsunami Hazard Area may be empirically defined using a deterministic approach, based upon the observed run-up and inundations during the Tsunami and the potential maximum wave heights for the scenario tsunamis. As found applicable, remote sensing and geographic information system (GIS) of the coastal areas may be used. For the terrestrial environment, the hazards may be presented as inundation levels, in terms of run-up heights at specified land contours. The definition of the tsunami hazard zones, as preliminary estimates, is given below. For Tsunami mitigation as well as development strategies in rural and urban areas, the coastal areas can be divided into four hazard zones, with zone 1 as the less dangerous zone and the zone 4 as the most dangerous zone.

The zones are defined as:

Zone-1 maximum water depth 0-3 m
Zone-2 maximum water depth 3-6 m
Zone-3 maximum water depth 6-9 m
Zone-4 maximum water depth > 9 m

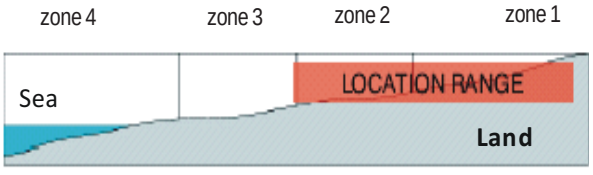


Fig. 2.1:
Tsunami Risk Zoning

Water depth range has been chosen according to the maximum number of storeys present in a building (e.g. 0-3 meters is a single floor building) that could be flooded by the tsunami wave. Coastal zoning has to be done taking into consideration results on wave propagation and inundation inland which are derived from numerical hydrodynamic models.

2.2.5 A probabilistic approach is necessary for evaluating tsunami hazard from nearby seismogenic sources as well as from distant sources because many uncertainties exist in a process of estimating tsunami heights along coastal areas from tsunamigenic source models. However, a Probabilistic Tsunami Hazard Analysis (PTHA) is not common in comparison with a Probabilistic Seismic Hazard Analysis (PSHA). The PSHA is a methodology for estimating the probability that specified levels of earthquake ground motions exceed at a given location in a given future time period by combining the probabilistic models of earthquake occurrence and earthquake-caused ground motion. On this basis, PTHA is to be carried out. Essentially it reflects the likelihood of exceeding certain wave parameters. This method can be developed based on source zone identification and

characterization, probability of earthquake occurrence, synthetic tsunami catalogue using Green's functions and validation of bathymetry models and uncertainty.

2.2.6 A logic tree approach can be used for evaluating uncertainty in tsunami hazard. Two kinds of uncertainty, aleatory and epistemic, are generally distinguished in the PSHA. Aleatory uncertainty is due to the random nature of earthquake occurrence and its effects. Epistemic uncertainties are due to incomplete knowledge and data about the earthquake process. A hazard curve will be obtained by the integration over the aleatory uncertainties and a large number of hazard curves will be obtained by the combinations of the model parameters that represent epistemic uncertainty using the logic-tree approach, combination of tsunami sources, magnitude distribution of characteristic tsunamigenic earthquakes, their recurrence interval, and tsunami height estimation procedure based on a numerical simulation to be defined as the nodes in the logic-tree. Each path of the logic tree generates a tsunami hazard curve. Accordingly many hazard curves are to be obtained systematically by the logic-tree.

2.2.7 Though very few tsunamis are known to have occurred in Indian Ocean, the historical catalogue of Pacific Ocean shows that most of the tsunamis are caused by submarine earthquakes. Tsunami occurrences due to volcanic eruption, landslide and meteorite impacts are relatively infrequent. Landslide triggered tsunamis can be a possible scenario in the Bay of Bengal and the Arabian Sea due to the huge sediment deposition by the Ganges and Indus Rivers. The primary cause of a tsunami being a submarine earthquake, a similar approach as used to define Design Basis Earthquake shall be followed for defining Design Basis Tsunami also.

2.3 Multi-Hazard Situation in Coastal Areas of States/UTs

2.3.1 The tsunami affected coast will have a small width of 500 m to about 1.5 km forming part of the coastal management zone. The areas in most cases will be subjected to severe cyclonic wind storms and storm surges which may even be higher than the tsunami run-up levels. Many of the areas in the deltaic plains of the rivers will be subjected to flooding under heavy rains. The Andaman & Nicobar Islands and the Kutch district of Gujarat are in the most severe Seismic Zone V and some coastal areas of Saurashtra and Maharashtra are in seismic zone IV. Besides, many coastal areas are in seismic zone III. This fact will have an important bearing while preparing the DM plans for the tsunami hazard zones on the coasts. The National Disaster Management Guidelines prepared by NDMA for the Management of Cyclones, Medical Preparedness and Mass Casualty Management and Psycho Social Health and Mental Health Services also provide inputs for the preparation of DM Plans in the coastal areas which are prone to tsunamis.

The assessment of vulnerability and risk and mapping thereof in the tsunami hazard area must be carried out taking the various other hazards as applicable. Many of the areas prone to tsunamis are also prone to storm surges caused by tropical cyclones. Hence, a multi-hazard approach will have to be followed for addressing the preparedness, mitigation and emergency response requirements in the coastal areas.

2.3.2 The multi hazard situation on the West & East coast of India is presented in the following tables.

Table 2.1
Multi Hazard Data for West Coast of India

Name of the Coastal State / UT	Seismic Zone	Design Cyclonic Wind [IS:875 (III)] (m/s)	Probable Maximum Storm Surge Heights (m)	Astronomical High Tide above Mean Sea Level (m)	Flood Proneness
Gujarat	V,IV,III	50 & 47	2.5-5.0	1.1-4.1	In 5 coastal districts
Dadra & Nagar Haveli	III	44	5.0	1.9	-
Daman & Diu	III	50 & 44	5.0	1.1	-
Maharashtra	IV & III	44 & 39	2.9-4.2	1.9	-
Goa	III & II	39	3.4	1.0	-
Karnataka	III & II	39	3.4-3.7	0.8	-
Kerala	III	39	2.3-3.5	0.8	In 9 coastal districts
Lakshadweep	III	39	**	0.5	-

** Storm surge occurrence of Lakshadweep has not been documented. However, storms originating over these areas are not intense enough to cause significant surges.

Table 2.2
Multi Hazard Data for East Coast of India

Name of the coastal State	Seismic Zone	Design & Probable Maximum Surface Wind (m/s)	Probable Maximum Storm Surge Heights (m)	Astronomical High Tide (m)	Flood Proneness
Tamil Nadu	III & II	50,47,39 (PMWS-64)	2.7-7.0 except 11.0 near Toni	0.5	-
Puducherry	III	50,47,39 (PMWS- 64)+	3.0-4.5	0.5	In 1 coastal district
Andhra Pradesh	III & II	50 (PMWS-78)+	3-6	0.68	In 8 coastal districts
Orissa	III & II	50 & 44 (PMWS-78)+	2.7-9.8	0.9-1.40	In 3 coastal districts
West Bengal	IV& II	50 (PMWS-78)+	12.0-12.5	2.6	In 3 coastal districts
Andaman & Nicobar	V	44	**	1.0	-

** Storm surge occurrence in Andaman & Nicobar Islands has not been documented. However, storms originating over these areas are not intense enough to cause significant surges.

+PMWS=Probable Maximum Wind Speed

2.4 Tsunami Vulnerability Assessment

2.4.1 The vulnerability assessment of both built and natural environment due to tsunami impact will be developed for shores and harbours by MoES. Potential damage from any Tsunami prevails because of hydrological effects to structures by pressure and suction, scouring and liquefaction, cracking and slumping. These result in structural damage to buildings, contents in the house, as well as damage to infrastructure (roads, bridges, water supply, sewerage, wharves, seawalls), and navigational aids. There is the potential for "seiching" in the shallow harbour areas where alternately (from the tsunami waves), water is drained from the harbour and then flooded to depths greater than high tide levels. The above damages also pose a threat to human life by causing death and injury.

2.4.2 Vulnerability can be defined as the predisposition of something to be affected because of inherent properties of a system, process and community. The vulnerability assessment is expressed as details of elements of the built, natural and human environments vulnerable to potential tsunami-related damage. The Tsunami Hazard Zones (THZs) consisting of terrestrial environments around the shores and the marine environments need to be included in the vulnerability assessment.

2.4.3 The generic lists of ecologically sensitive areas and areas of particular concern are stated below:

a) The ecologically sensitive areas include mangroves; coral reefs; sand beaches; sand dunes; inland tidal water bodies, i.e. estuaries, lakes, lagoons, creeks; mudflats; marine wildlife protected areas under the Wildlife (Conservation) Act; coastal fresh water lakes; salt marshes ; turtle nesting grounds; horse shoe crab habitats; sea grass beds; sea weed beds and nesting grounds of migratory birds.

b) The areas of particular concern include: coastal municipalities/corporations (the entire notified area); coastal panchayats with population density more than 400 persons (entire notified area) as per the latest Census of India; ports and harbours; notified tourism areas; mining sites; notified industrial estates; Special Economic Zones; cultural heritage areas; notified archaeological sites under the Protected Monuments Act; Critical Defence areas/installations; power plants; and other strategic installations.

2.4.4 Preparation of Coastal Vulnerability map will involve the following tasks.

a) Preparation of coastal land use map on large scale.

b) Wave (tsunami) run up height modeling and inundation distance based on coastal bathymetry.

c) Preparation of Digital Elevation Models (DEMs) at appropriate locations, and

d) Creation of inundation scenario using the above information.

While integrating the spatial data on the key parameters, the most dynamic

parameter is the wave run up height which will depend upon the amplitude and wavelength of the tsunami waves. Models need to be developed to estimate the time of arrival of the tsunami waves at a particular point in the coastal area and the estimated wave run up height. This can be then used to generate the inundation scenario. Estimation of the travel time of the tsunami waves, the breaker height and the wave run up height will also require data on bathymetry. Social vulnerability factors include lack of local institutional mechanisms, appropriate skills, local investments, rapid population changes, deforestation, decline in soil fertility, local income level, social relations, cultural issues etc. These factors are to be integrated into the vulnerability analyses. Vulnerability analyses help in identifying the areas that need targeted assistance and help.

2.4.5 A *risk* to a natural event is defined as the mathematical product between *vulnerability* and *hazard*; it refers to the expected loss from a given hazard to a given element at risk. Vulnerability is defined as the potential for damage while hazard, for a tsunami event, is defined as the potential height of the wave. Risk management is a two-part process involving risk assessment and risk evaluation.

2.4.6 Risk assessment is mainly a scientific and quantitative exercise resulting from an analysis of field and/or experimental data (e.g. modelled tsunami wave height) and from an overall understanding of the nature of the hazard and vulnerability parameters. Risk evaluation links perceived risk to a broader qualitative analysis which includes, for example, cost benefit trade off and socio-economic impact. In the case of a Tsunami event, the main vulnerability parameters are: population, built-up areas, infrastructure, the ecosystem and the environment. For each of these parameters a list of sensitive elements has to be compiled. Sensitive elements are those characteristics of the parameter under consideration that could be most affected by a tsunami wave. Summation of the sensitive elements defines the vulnerability of a chosen parameter.

2.4.7 Vulnerability level for each vulnerable parameter, viz. population, built environment, infrastructures, ecosystem and environment is calculated using a multi-criteria analysis. Multi-criteria analysis is a decision making process. Outcome of the multi-criteria analysis is the vulnerability level of the chosen parameter. First step is to identify the sensitive elements, i.e. characteristics of the parameter under consideration that could be most affected by a tsunami wave. For example, for the built environment, sensitive elements are: building material (m) ; description of ground floor (g) ; number of stories (s) ; design (d); foundations (f); etc. Further, the weighting criteria, i.e. criteria identifying the type of damage (structural and damage due to flooding) may be worked out. Sensitive elements are evaluated against weighted criteria and by means of cross related evaluation grid, a final value of vulnerability level is estimated.

2.4.8 Geographic Information Systems (GIS) will be prepared and subjected to continuous updating process for a better and more user-friendly usage of the risk assessment and evaluation exercise. Vulnerability maps are loaded into a GIS system containing information on hazard and risk. The process that gets the risk map can be conceived as an overlapping of the hazard maps and the vulnerability maps.

2.4.9 For the purpose of prognosis, a data base of tsunami height in the ocean and on land, and the time of arrival of the tsunami wave at

the site can be generated by postulating various events at different locations on the tsunamigenic sources. In the event of an actual tsunami, this data base can be made use of to forecast the progression of the tsunami wave, and issue warnings to the various agencies. The first indication can be had from the seismic signal. This process will be continuously updated based on further seismic data and the data from various instruments deployed in the ocean. Based on these updated assessment of the tsunami waves, height and assessment of inundation can be made and suitable advisories can be issued by the designated authorities. The prognostic model can be verified by re-run of past tsunami data.

2.5 Role of the Indian Naval Hydrographic Department (INHD)

2.5.1 The Indian Naval Hydrographic Department (INHD) functions under the Chief Hydrographer to the Government of India. The Department, being the nodal agency for Hydrographic surveys and Nautical charting in India, has a very well established organizational setup. INHD has eight indigenously built modern survey ships based strategically along India's East and West coast namely at Karwar, Kochi and Visakhapatnam and a well established 'National Institute of Hydrography' which is recognized as the 'Regional Centre for Imparting Training in Hydrography' for South East Asia by IHO. The department also pioneered in making official Electronic Navigational Charts (ENCs) for Indian waters apart from providing ancillary information through numerous allied publications. The bathymetry information available with the INHD forms the basis for drawing up inundation maps as required for cross sectional area assessment of waves and storm surges during natural calamities.

INHD shall regularly provide bathymetry information to authorized agencies for drawing the inundation maps. The SoI, NRSC, INHD and State Remote Sensing Application Centres must provide inputs to the MoES for preparing the DM Plans.

2.6 Use of Satellite Imageries in Monitoring

2.6.1 Unlike earthquakes, numbers of Tsunami events are far less to have a comprehensive data base of various hazard parameters. Since most of the data base needs numerical simulation, it would be appropriate to generate coastal maps of multi-hazard risk, land use planning, natural drainage contours, dynamics of river basins etc. on a comprehensive GIS platform. With ground level benchmarking of field data, several satellite imageries could be processed for extracting and generating the necessary thematic maps for the Tsunami hazard assessment.

3 Tsunami Preparedness

3.1 Warning System Components and Instruments

3.1.1 The following are the components of a tsunami early warning system:

- A Network of Land-based Seismic Stations for earthquake detection and estimation of source parameters in the two known tsunamigenic zones (viz. Java-Sumatra-Andaman-Myanmar belt and the North Arabian Sea) that would affect the Indian Ocean region and communicating the same to Early Warning Centre in near-real time.
- Detection of Tsunami generation through a network of 10-12 bottom pressure recorders (that could detect and measure a change in water level of 1 cm at water depths of up to 6 km of water) around these two tsunamigenic zones,
- Monitoring the progress of Tsunami and Storm Surges through a network of 50 real time tide gauges,
- Tsunami Modelling (addressing the inundation and amplification all along the coast and islands for different tsunami originating from different sources),
- Generating and updating a high resolution data base on bathymetry, coastal topography, coastal land use, coastal vulnerability as well as historic data base on Tsunami and Storm Surge to prepare and update Storm Surge/ Tsunami hazard maps in 1:5,000 scale (for coastal areas within 1-3 km in general and for 10-25 km at selected areas near coastal water bodies),
- Setting up a dedicated National Early Warning Centre (NEWC) for monitoring tsunamis and storm surges in India for operation on 24x7 basis and for generation of timely advisories, and
- Capacity building, training and education of all stakeholders on utilisation of the maps, warning and watch advisories.

3.1.2 As part of the Early Warning System for Tsunamis and Storm Surges in Indian Ocean set up by GoI, a 17-station Real Time Seismic Monitoring Network (RTSMN) is envisaged to be established by IMD. This network is designed to monitor and report the occurrence of earthquakes capable of generating Tsunamis from the two probable Tsunamigenic sources viz., Java-Sumatra-Andaman-Myanmar belt and the north Arabian Sea area in the least possible time. The data from the 17 Broadband seismic field stations will be transmitted simultaneously in real time through VSAT communication facilities to the Central Receiving Stations (CRS) located at IMD at New Delhi and INCOIS, Hyderabad for processing and interpretation.

The CRS are equipped with state-of-the-art computing hardware, communication, data processing, visualization and dissemination facilities. The earthquake information shall be disseminated through various communication channels to all concerned user agencies in a fully automated mode. The main features of the Real Time Data Processing software at the CRS are given below:

- Sounding Earthquake Alert based on first information to NEWC;
- Real time estimation of hypocentral and source parameters (viz., time, latitude, longitude, depth, magnitude ML, Mb, Ms, Mw, Mwp as the case may be) ;
- Seismic waveform data sharing with international community through Gateway Hub located at the NEWC at INCOIS, Hyderabad from the selected stations (Port Blair, Bhuj, Shillong and Hyderabad) for earthquakes of magnitude 6.0 and above from Tsunamigenic sources ;
- Estimation of dynamic source parameters, such as Centroid Moment Tensor (CMT) solutions, source duration, displacement etc. ;
- Fault Plane Solution from waveform inversion ;
- Assessment of type of faulting involved in the earthquake and the possibility of tsunami generation ;
- Multi-Channel graphic display of waveform and derived products ; and
- Extensive data dissemination capabilities to decision making authorities through automatic generation of Fax, SMS and Email messages and response from dedicated Telephone answering machines.

3.1.3 For the purpose of prognosis, a data base of tsunami height in the ocean and on land, time of arrival of the tsunami wave at the site can be generated by postulating various events at different locations on the tsunamigenic sources. In the event of an actual tsunami these data base can be made use of to forecast the progression of the tsunami wave, and issue warnings to the various agencies. The first indication can be had from the seismic signal. This process will be continuously updated based on further seismic data and the data from various instruments deployed in the ocean. Based on these updated assessment of the tsunami waves, height and assessment of inundation can be made and suitable advisories can be issued through the concerned authorities. The prognostic model can be verified by re-run of past tsunami data.

3.1.4 In order to quickly confirm existence or otherwise of Tsunami waves following an earthquake, and also for monitoring the progress of tsunami and later for cancellation of warning, it is essential to monitor the sea level and this calls for a network of real-time Tide Gauges installed in strategic locations. The real-time Tide gauges are also essential component of the storm surge monitoring system. Such a network of tide gauges may be the only way of detecting a Tsunami in cases where seismic data are not available or when the Tsunami is triggered by events other than an earthquake.

3.1.5 As part of the National Tsunami Early Warning System, 50 state-of-the-art Tide gauges (36 by SOI and 14 by NIOT) are being

installed at strategic locations along the Indian Coast as well as a few of the Off-shore platforms connected to the Early Warning Centre. VSAT connectivity has already been set up between NIOT, SOI and INCOIS for real-time reception of the data at the Early Warning Centre. INCOIS has developed necessary software for real-time reception, display and archiving of tide gauge data.

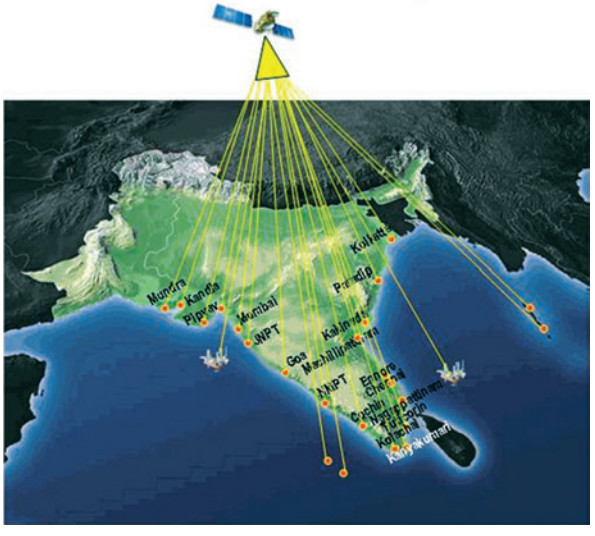


Fig. 3.1:
Typical Locations of Real-time Tide Gauges

3.1.6 In order to confirm whether the earthquake has actually triggered a Tsunami, it is essential to measure the change in water level in the open ocean with high accuracy. Bottom Pressure Recorders (BPRs) are used to detect the propagation of Tsunami waves in the Open Ocean and consequent sea level changes. A network of Bottom Pressure Sensors (BPSs) are being installed close to the tsunamigenic source regions to detect tsunami.

3.1.7 The System consists of an anchored sea floor Bottom Pressure Recorder (BPR) and a companion Moored Surface Buoy for real time communications. The BPR uses a piezoelectric Pressure transducer to make 15 seconds-averaged measurements of the pressure exerted on it by the overlying water column. The Tsunami detection algorithm running in the BPR generates predicted water height values and compares all new samples with predicted values. If two 15-second water level values exceed the predicted values, the system will go into the 'Tsunami Response Mode'. Data will then be transmitted on the Random channel for a minimum of 3 hours, giving high frequency data on short intervals with 100% repeated data for redundancy for the first hour. An acoustic link transmits data from the BPR on the sea floor to the surface buoy. The data are then relayed via a communication satellite (e.g. GOES) finally to the Tsunami Warning Centre. In the 'Standard mode', the System reports, every hour, only four 15-minute average values of sea surface height. The present locations for Deep Ocean Bottom Pressure Recorders with Surface Buoy system for covering the two known Tsunamigenic Zones of the Indian Ocean are given at Fig.3.2.

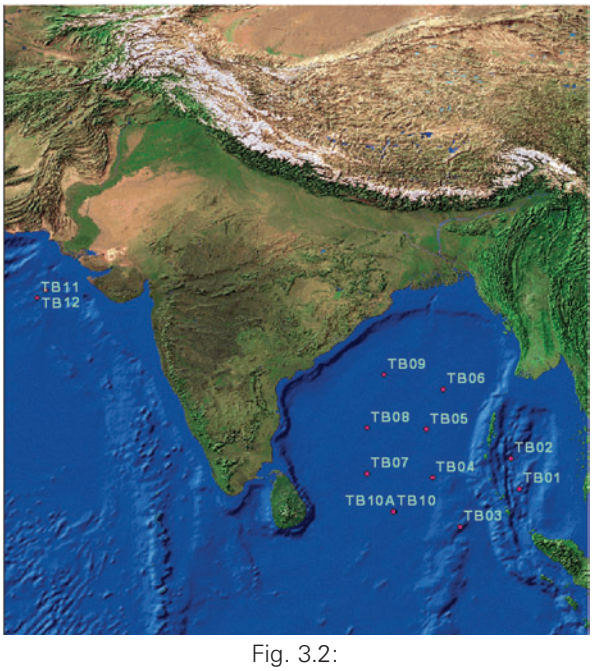


Fig. 3.2:
Locations of Deep Ocean
Bottom Pressure Recorders

3.1.8 Twelve BPRs (10 in the Bay of Bengal and 2 in the Arabian Sea) are being installed in the Bay of Bengal and the Arabian Sea at appropriate locations. To date, 4 BPRs in Bay of Bengal and 2 BPRs in the Arabian sea have been deployed and remaining 6 BPRs are going to be deployed in the near future.

The critical gaps in the availability of monitoring instruments like BPRs, tide gauges, surface buoys, etc. to cover the Bay of Bengal, Arabian Sea and the Indian Ocean for close monitoring of tsunamigenic behaviour will be carried out by MoES urgently on priority. The MoES will carry out an assessment of the feasibility of the existing installations to cover the potential tsunami-prone areas and augment the installation of all instruments as per this assessment to ensure that all possible tsunamigenic behaviour patterns are captured as early warning and alert messages through this augmented network.

3.1.9 It is globally a major concern that the unattended ocean observation platforms including the Deep Ocean Tsunami Wave Detection Buoy System (Tsunameter) in sea are being vandalized either accidentally or intentionally and has become detrimental to the data availability during the Tsunami event. As such, the failures of tsunami buoys data reporting due to vandalism should be addressed on priority. It is necessary to create the public awareness, more particularly among the fishermen and mariners, about the importance of such a system for hazard prevention and mitigation and the need to protect such a system at high sea. The awareness campaigns should also bring out the efforts of scientists and engineers in designing and developing such hi-tech devices and its deployment in high sea as well as its up-keeping even during the harsh sea conditions, apart from the large expenditure involved in developing such systems. There should be a regular awareness campaign through print and electronic media informing the general public, especially fishermen, about Tsunami Buoy features, its importance and protection needs. Further, the coastal villages should also be well informed about such scientific instruments through leaflets and posters, apart from the media news in the respective regional languages. Towards this, the International organizations like Data Buoy Cooperation Panel (DBCP), a joint body of IOC (Intergovernmental Oceanographic Commission) and WMO (World Meteorological Organization) has initiated many actions to create public awareness and also to issue Mariner's notification by International Hydrographic Organization (IHO) through the respective National Hydrographic Offices on the location of buoys to advise fishermen and mariners to keep off their fishing and trawling operations away from the buoy sites. The National Institute of Ocean Technology (NIOT) has implemented the National Data Buoy Programme and has taken special efforts in the protection of Surface data buoys from vandalism to a large extent with the help of Indian Coast Guard, with the latter carrying out regular patrolling of the buoy sites. NIOT ensures that whenever a new data buoy or a tsunami surface buoy is installed, this information is communicated to the mariners through the release of mariners notification by National Hydrographic Office (NHO) with a clear instruction to keep off their fishing and trawling operations by 3 km from the buoy sites. Such efforts shall need to be continued with high priority to ensure the smooth fail-safe functioning of these critical instruments.

3.1.10 The efforts for surveillance of the safety of the critical early warning instrumentation in the Bay of Bengal and the Arabian Sea will be augmented preferably with the specialised aircraft available with National Remote Sensing Centre (NRSC) and where available with Unmanned Aerial Vehicles (UAVs) with the help of Indian Air Force, Indian Navy and Coast Guard patrols to ensure the fail-safe functioning of these critical instruments and their protection from vandalism by fishermen and mariners.

3.1.11 The MoES and the nodal institutions like INCOIS, NIOT and IMD will participate in the ongoing multilateral and bilateral cooperation initiatives in sharing information about possible tsunamigenic behaviour with their counterpart nodal agencies in the neighbouring countries through appropriate channels worked out through mutual consultations.

3.2 Warning on Inundation of Critical Areas

3.2.1 Tsunamis and cyclonic storms result in generation of waves of different period and height that are termed as surges. These wave parameters depend on earthquake source parameters, bathymetry, beach profile, coastal land topography and presence of coastal structures. These surges cause flooding of seawater into the land as much as 1 km or even more resulting in loss of human life and damage to property. To minimise such losses, it is imperative to prepare Coastal Vulnerability maps indicating the areas likely to be affected due to sea water inundation and damage thereof. Simulation Models such as TUNAMI-N2 and MOST, being globally used for this purpose, predict surges for different scenarios and indicate the extent of inundation of seawater into the land. Physical scaled hydrological models could also supplement the simulation like the DAM-models used in the Central Water and Power Research Station (CWPRS), Pune. This information could be used for taking precautionary and mitigation measures such as evacuation of people, avoiding human settlements on vulnerable locations, wasteful investment, and helping in design of appropriate structures etc. in the risk prone areas. Information from remote sensing and field investigations are being integrated in GIS for modelling and mapping of inundation of seawater for determination of setback lines, planning coastal defences etc.

3.2.2 TUNAMI-N2 Model has been customised by ICMAM for the Indian Ocean Region and has been extensively validated using the December 2004 Tsunami observations. This model is now being run for 5 historical earthquakes and the predicted inundation areas are being overlaid on cadastral level maps of 1:5000 scale. The maps will be provided to the Ministries and Departments of the Government of India and state level departments that are involved in Disaster Management. These community-level inundation maps will be extremely useful for assessing the population and infrastructure at risk. They could be used for better land-use planning, building of shelters, planning evacuation routes, etc. A typical inundation map prepared by ICMAM based on the 26th December 2004 earthquake and tsunami for Nagapattinam is shown at Fig.3.3.

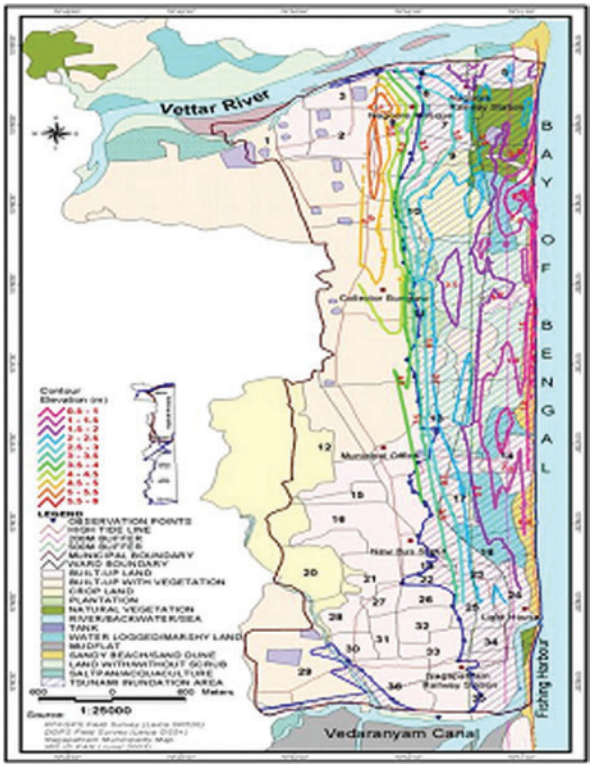


Fig: 3.3.
Tsunami Inundation Map, Nagapattinam

3.3 Decision Support System and Standard Operating Procedures

3.3.1 The Indian Tsunami Warning Criteria are based on the principle that coastal areas falling within 60 minutes travel time from a tsunamigenic earthquake source need to be given a Warning, Watch or Alert based solely on earthquake information and run ups estimated from Model Scenarios, since enough time will not be available for confirmation of water levels from BPRs and Tide Gauges. Those coastal areas falling outside the 60 minutes travel time from a tsunamigenic earthquake source could be put under Alert/Watch status based on expected run-up and upgraded to a Warning only upon confirmation of water-level data. This will considerably reduce the rate of False Alarms. The following criteria are being followed for generation of Tsunami bulletins:

- Warning/Alert/Watch based on earthquake parameters, a region's proximity to earthquake zones (Travel Times), and Expected Run-up from Pre-run Model Scenarios.
- Warnings to Far Source Regions only after confirmation of tsunami triggering based on real-time water-level observations & Correction of Scenarios. This will reduce the possibility of False Warnings.

3.3.2 The criteria for generation of different types of alerts (Warning/Watch) for a particular region of the coast are to be based on the earthquake parameters, available warning time (i.e. time taken by the tsunami wave to reach the particular coast) and expected run-up from pre-run model scenarios.

3.4 Tsunami Bulletins and Warning Categorisation

3.4.1 Category of tsunami bulletins, time-line for generation, content of the alert and dissemination contact information is detailed below:

- Earthquake Information Bulletin (T+20 Minutes) contains information about Origin time, latitude and longitude of the epicentre, name of geographical area, Magnitude, and Depth of an Earthquake. This message also contains preliminary evaluation of tsunami potential based on the magnitude. (for example, earthquake happening on land or earthquake with M < 6.5, or earthquake hypocentre

occurring at depth greater than 100 km or earthquake happening in very shallow water column, etc. no Tsunami is expected; for larger magnitude earthquakes in the ocean, a qualitative statement on the tsunamigenic potential may be given). Though information is provided to Ministry of Home Affairs (MHA), NDMA and NCMC, no immediate action is required.

- Tsunami Warning (T+30 Minutes) contains information about the Earthquake and a tsunami evaluation message indicating that Tsunami is expected. (eg. for earthquakes with M > 6.5 occurring in the ocean within a hypocentral depth of less than 100 km, a Tsunami Warning will be issued for those areas falling within 60 minutes travel time from the earthquake source and if expected Run up is greater than 2 metres). This is the highest level wherein immediate public evacuation is required. Message also contains information on the Travel Times and Tsunami Grade (based on run-up estimates) at various Coastal Locations from Pre-run Model Outputs. Information on above is provided to MHA, NDMA, NCMC, NDRF Battalions and the general public.
- Tsunami Alert (T+30 Minutes) contains information about the Earthquake and a tsunami evaluation message indicating that Tsunami is expected. (eg. For Earthquakes with > 6.5 M occurring in the Ocean within a hypocentral depth of less than 100 km, a Tsunami Watch will be issued for those areas falling within 60 Minutes Travel Time from the Earthquake Source and if Expected Run up is between 0.5 to 2 Metres). This is the Second Highest Level wherein immediate public evacuation is not Required. Public should avoid beaches since strong current are expected. Local officials should be prepared for evacuation if it is upgraded to warning status. Message also contains information on the Travel Times and Tsunami Grade (based on run-up estimates) at various Coastal Locations from Pre-run Model Outputs. Information on above circumstance is provided to MHA, NDMA, NCMC, NDRF Battalions and the general public.
- Tsunami Watch (T+30 Minutes) contains information about the earthquake and a tsunami evaluation message indicating that Tsunami is expected. (example, for earthquakes with M > 6.5 occurring in the Ocean within hypocentral depth of less than 100 km, a Tsunami Watch will be issued for those areas falling within 60 minutes Travel Time from the Earthquake Source and if expected Run up is less than 0.5 meters). This is the Third Highest Level wherein immediate public evacuation is not required, local officials should be prepared for evacuation if it is upgraded to warning status. Message also contains information on the travel times and Tsunami grade (based on run-up estimates) at various coastal locations from Pre-run model outputs. The above information is provided to

MHA, NDMA, NCMC and NDRF Battalions.

- Tsunami Information Bulletins contain information on Tsunami Confirmation (wherever a Tsunami Warning already Exists) or Upgradation (Watch to Alert to Warning or bringing new areas under Watch) or Cancellation (withdraw Watch or Alert or Warning) or Observed Water Level Heights or New estimates of Travel Time and Tsunami Grade (generated by inverting observed water-level data) and any other additional information that becomes available during the course of the Event.
- Tsunami All Clear Bulletin indicates that the Tsunami Threat is over.

3.4.2 The Tsunami bulletins are to be allotted on precedence under the categories of FLASH, EMERGENCY, OPS IMMEDIATE, PRIORITY and ROUTINE as tabulated below. These precedence signify the speed of handling and transmitting of communication of the bulletins by the recipients as well as the speed at which corresponding emergency actions need to be taken. These precedence are to be marked clearly and boldly in uppercase on the header and footer of all text, fax and email messages. The colour code scheme is to be used for highlighting the text in text and email messages, and for web pages appropriately.

Table:3.1
Tsunami Bulletin Categories

Warning Category	Precedence	Remarks
Tsunami Warning (T+30 minutes)	FLASH	- *NO DELAY* in handling/actions - Requires Audio, Visual Alarm - RED Colour
Tsunami Alert (T+30 minutes)	EMERGENCY	- *NO DELAY* in handling/actions - Requires Audio, Visual Alarm - *ORANGE* Colour
Tsunami Watch (T+30 minutes)	OPERATIONAL IMMEDIATE	- *NO DELAY* in handling/actions - Requires Audio, Visual Alarm - *YELLOW* Colour
Tsunami Information	ROUTINE	- Upto 15 min delay acceptable - No Audio, Visual Alarm/Alerts - *BLUE* Colour
Tsunami Cancellation	PRIORITY	- *NO DELAY* in handling/Actions - No Audio, Visual Alarm/Alerts - *GREEN* Colour
Tsunami All Clear	PRIORITY	- *NO DELAY* in handling/Actions - No Audio, Visual Alarm - *WHITE* Colour

Warning Timelines and Dissemination Actions for tsunami warning is mentioned below in Table 3.2.

Table: 3.2
Warning Time Line & Dissemination Actions

T_0	Earthquake Occurrence
T_0 + 20	Detection of Tsunamigenic Earthquake: Earthquake Information Bulletin: • A ROUTINE Tsunami Information Bulletin to be issued by NEWC to MHA, NDMA, NCMC, NDRF Battalions and MoES. This also contains preliminary evaluation of tsunami potential based on the magnitude. • (Regular status reports may be issued to MHA, NDMA, NCMC, MoES as required by NEWC).
T_0 + 30	*Earthquake expected to generate Tsunami, (on ocean, >6.5 Richter magnitude, <100 km Depth):* • A Warning/Alert/Watch will be issued by the NEWC based on scenario database results • Near Coastal Areas (< 60 min travel time of waves). o Warning: > 2 M Expected Run-up - FLASH - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media o Alert: 0.5 - 2M Expected Run-up - Emergency - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media o Watch: < 0.5 M Expected Run-up - Ops - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC • Far Coastal Areas (> 60 min travel time of waves). o Alert: > 2M Expected Run-up - Emergency - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC o Watch: 0.5 - 2 M Expected Run-up - Ops - MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC
T_0 + 30 - T_0 + 120	Confirmation of Tsunami Generation *Tsunami not Triggered* • NEWC to withdraw Tsunami Alert and Tsunami Watch Bulletins and issue Tsunami Cancellation Bulletin to NEOC, MHA, NDMA, NCMC, NDRF Battalions, MoES and concerned near area SEOCs and DEOCs, public and media.
T_0 + 30 - T_0 + 120	*Tsunami Triggered* • NEWC to issue upgraded Tsunami Bulletins to various coastal regions. • Upgrade Tsunami Advisory Bulletin to Tsunami Watch Bulletin and Tsunami Watch Bulletins to Tsunami Alert Bulletin to NEOC, MHA, NDMA, NCMC, NDRF Battalions, MoES and concerned SEOCs and DEOCs.

3.4.3 The communication channels to be used by NEWC for dissemination of the Tsunami Bulletins to the various entities is depicted below.

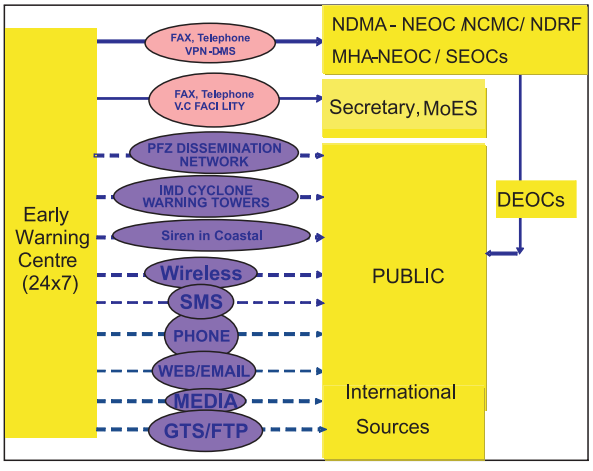


Fig. 3.4:
NEWC: Communication Channels

3.4.4 Tsunami Alert, Watch and Advisory Bulletins received at the NEOC, SEOCs and DEOCs need to be disseminated through the fastest means to the people in the coastal areas likely to be affected. With receipt of information, respective SDMAs and DDMAs are to:

- Establish and maintain an emergency public information capability that includes the following:
  - o A central contact facility for the media ;
  - o A system for gathering, monitoring, and disseminating emergency warnings ;
  - o Pre-scripted information bulletins ; and
  - o A method to coordinate and rapidly disseminate information.
- Ensure judicious and innovative use and integration of all communication resources available, such as Public Address systems through digital bulletin boards, local radios, local cellular/mobile network, and state and private television networks for dissemination of warnings received at their EOC nodes to the people in the coastal areas.
- Erect warning towers with sirens in all villages / districts and inhabited localities on the coastal areas vulnerable to Tsunami. A system of colour coded flag warning signals to be formulated appropriate to local culture, traditions, sentiments and acceptance.
- Provide digital bulletin boards in all villages and inhabited localities on the coastal areas. These should be workable in vernacular/local languages.
- Formulate appropriate warnings and sirens in vernacular as per local acceptance and institutionalise them.
- Maintain record of telephone numbers and mobile numbers of village centres, heads and local community leaders where available. A minimum of two volunteers per village/locality, to be responsible for communicating Tsunami Bulletins, are to be identified and provided with telephone/mobile phone connectivity. Their details and contact numbers are to be available in the SEOCs and DEOCs.
- Erect 'Tsunami Escape' direction sign boards indicating the escape routes to be taken in the event of a tsunami.

- Earmark and assign 'Assembly Point/ Areas' and 'Shelter Areas'. Clear ground in tsunami safe zones need to be established as 'shelter areas'. The 'shelter areas' need to be adequate for the overall local population.
- The communication resources and methods are to be integrated into the village resource centre with the overall NECP network in accordance with the NECP plan guidelines, where possible, and elsewhere, as per local configuration.
- Formulate detailed Standard Operating Procedures (SOPs) for the dissemination of Tsunami Warning Bulletins specific to each level, viz. district, sub district and village/ community level.
- The communication systems and procedures established are to be regularly tested and exercised, especially at the level of villages and localities in risky areas to support the tsunami warning mechanism. Organisations such as the Indian Red Cross Society, Civil Defence, NYKS, Home Guards, etc. shall be given the specific responsibility for conducting such events as a part of community based multi-hazard preparedness.
- Emergency communications and warning protocols, systems, processes, and procedures are to be developed, periodically tested, and exercised to alert people likely to be affected by a tsunami.
- Sirens along the coast line, mobiles and wireless networks being provided as a part of the National Cyclone Risk Mitigation Project (NCRMP) in Phase I in the eastern coast and in other coastal districts in Phase II will also be used to disseminate warning and alert messages to the coastal communities.
- State governments will utilize the NDRF Battalions to carry out community capacity building, public awareness and emergency response training, with the approval of NDMA.

3.5 Tsunami Early Warning Dissemination

3.5.1 The National Emergency Communication Plan (NECP) connectivity network will form the backbone architecture for the dissemination of Tsunami Advisory, Watch, Alert and Cancellation Bulletins. The network based on satellite communication links and ISDN public network will link the National Tsunami Early Warning Centre with the NEOCs, the SEOCs, DEOCs, MEOCs and NQRTs. Fail proof and reliable communication links for voice, facsimile, data, FTP, video conferencing and video information dispatch will be provided between all the nodes. In addition to the

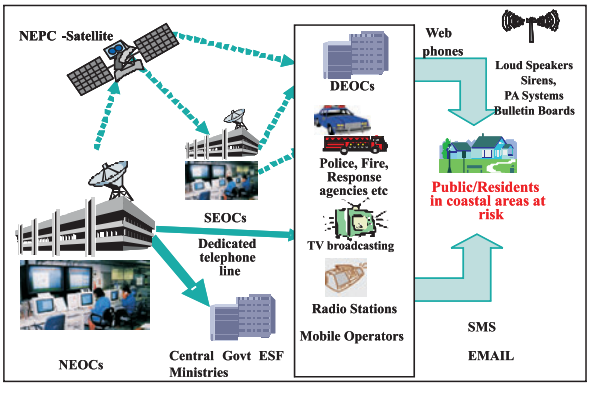


Fig. 3.5:
National Emergency Communication Plan

primary links (Satellite/VSAT between the NEOCs and the SEOCs; ISDN between SEOCs and DEOCS/NEOCs) two back up layers will be provided to ensure redundancy and 100 % availability.

First Backup layer

- NEOC↔SEOC↔DEOC : NICNET VSAT
- DEOC↔SEOC↔NEOC : POLNET VSAT

Second Backup layer

- NEOC↔SEOC : ISDN Dial Up
- DEOC↔SEOC/NEOC : NICNET VSAT

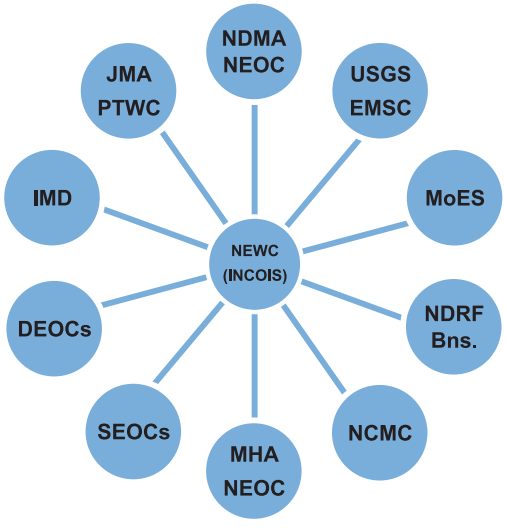


Fig. 3.6:
Tsunami Warning Network of NEWC

Facilities to be Supported

Voice
Fax
Data (text, email, FTP)
VPN - DMS
Video
Web
Graphics
Sound Alerts/Alarms

3.5.2 The National Early Warning Centre (NEWC), INCOIS will keep 24 x 7 operations watch and communicate Tsunami Advisory, Watch and Alert Bulletins to local, state, national and international entities as well as media, and the public.

3.5.3 The NEWC will be connected and networked with the NEOC, the nerve and decision center for all emergency communication, on the NECP architecture and will incorporate the VPN- DMS communication of ISRO.

3.5.4 The NDRF Battalions located in the coastal states will be also treated as primary nodes for the dissemination of tsunami alert and warning messages.

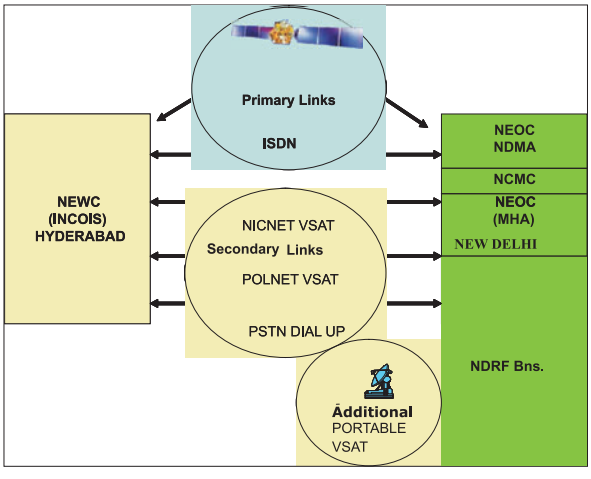


Fig. 3.7:
Connectivity of NEWC & NEOC

3.6 Roles and Responsibilities in Warning Dissemination

3.6.1 Tsunami watch, warning and information bulletins are disseminated by appropriate officials, institutions, and agencies. Their role and responsibilities need to be clearly specified and notified. A quick checklist is given below:

Institution	Role	Responsibilities
IMD	Seismic Network	Monitoring Earthquake, rainfall, flooding to provide drainage paths
INCOIS	Watch & National Tsunami Warning Centre	Monitor and provide information based on predictive models
MHA	Warning & information bulletins	Issue warning & periodic bulletins
State Relief Commissioner (SRC) / Secretary (DM)	Watch & warning	Issue site specific warning in the State based on the inundation warning and feedback to MHA
District Collectors	Watch & information feed back	Issue site specific warning within the district based on SRC & ground level feed back to SRC
Ports / harbours / coast guard/ marine enforcement and other local public offices	Warning & feed back	Sign boards & announcements. Feed back to District Collector
Police (local)	Warning & feed back	Voice announcements at the site. Feed back to District Collector
Local NGOs and groups	Warning & feed back	Voice announcements at the site
Visual media & radio	Warning & feed back	Direct broadcast and feed back to all
Mobile/SMS/VHF	Warning & feed back	Direct broadcast and feed back to all

3.7 Role of Media in Warning Dissemination

3.7.1 The media is a powerful ally for disseminating the alert and early warning to the general public and other stakeholder groups. The media elements are to:-

- Establish and indicate nodal points for receiving Tsunami Warning Bulletins to the respective SDMAs/DDMAs.
- Integrate all regional and local offices of the media elements with the NECP network up to the DEOC level.
- Institutionalise SOPs for transmitting Tsunami Warning Bulletins as received by the nodal points.
- Incorporate measures in the various media channels and processes to ensure priority override for transmitting Tsunami Warning Bulletins as required.
- To build capacity for the Media professionals to ensure that the correct level of warning is made available at the right time. Spreading rumours should not be permitted,

because these may generate panic and result in stampede.

3.8 Coordination Mechanisms

3.8.1 The Tsunami Early Warning System involves a large number of government and other agencies under the present three tier disaster management structure, i.e. the national, state and district. A Coordination Committee comprising of representation from NDMA, NCMC, MHA, MoES (IMD, INCOIS), DST, MCIT, MoIB, Prasar Bharti (All India Radio and Doordarshan) constituted under the NDMA, will meet bi annually to review the status, future developments and upgradation of facilities, procedures and systems.

3.8.2 Establishing appropriate institutional and collaborative linkages for providing technical and support services at various levels is a key requirement for sustaining the proper development and implementation of the tsunami warning dissemination mechanism. The corporate sector, industries, academia, NGOs, and other concerned agencies will extend a helping hand in training and building capabilities and shall provide their expertise in the field of capabilities, resources, technical expertise, trained personnel, equipment etc. A comprehensive list of national and state level institutions for the development of technology, processes, practices, procedures and other measures is to be identified and established at national, state and district levels. Collaborative arrangements between these are to be formulated at the national and state levels. The state governments shall also ensure that the identified institutes are provided sufficient resources and all necessary help extended for working on novel technologies and initiatives, including training communities and groups.

India will participate in the international effort at improving the quality of preparedness and response by liaising with international organisations, UN agencies and other humanitarian actors and share the best practices in tsunami preparedness and mitigation.

3.9 Research and Development Efforts

3.9.1 There is need to develop high-resolution models for tsunami wave propagation in the Indian Ocean. Tsunami wave propagation in the Indian Ocean is very complex when compared to the Pacific Ocean. The propagation characteristics have to be understood fully and peculiar features specific to the Indian Ocean have to be incorporated in the models in order to achieve high accuracy and reliability in the predictions. The following are some of the important aspects in which R & D efforts could be concentrated:

- Initial withdrawal of the oceans (IWO); there is lack of a complete understanding of this phenomenon even in the international scenario.
- Time of arrival of tsunami waves; the available tsunami travel time atlas provides travel time for the first wave, it doesn't provide information on the arrival times of subsequent waves or the number of waves in a tsunami event, which will be the highest, etc.
- Influence of hydrodynamic parameters on tsunami wave propagation; this needs to be studied with reference to the hydrodynamic regime of the Indian ocean, i.e. tides, waves, currents, internal waves, etc. There are several distinct hydrodynamic characteristics unique to the Indian Ocean.

- Tsunami inundation characteristics: studies have to be carried out for the entire coastline of the country; locations of focusing of tsunami energy due to bathymetric features will be brought out by such studies. Action is underway to conduct scenario analysis by modelling propagation of tsunami and storm surge. The models will be used to prepare inundation levels based on any tsunamigenic earthquake. Using high-resolution offshore bathymetric and onshore elevation data will improve the results of the models. Continuous efforts should be undertaken to update the inputs for the models and also to prepare inundation models at tsunami-prone village levels.
- Reflection, energy trapping and secondary oscillations; the presence of chains of islands in the ocean makes reflection an important process. Energy trapping and secondary oscillations need to be studied to predict the duration of water level oscillations due to tsunamis.
- Total internal reflection; the presence of chain of islands in the Indian Ocean offers scope for propagation of waves from shallow to deep water, leading to total internal reflection.
- Characterization of tsunamigenic sources in the Indian Ocean; identification of tsunamigenic sources enable modelling of tsunami propagation and preparation of tsunami inundation charts specific to different scenarios of tsunami generation from these sources. Knowledge of fault geometries of the subduction zones will also be acquired.
- Paleo-tsunami and paleo-seismological studies; these studies provide long term data on past earthquakes and tsunamis by identifying, mapping and dating prehistoric and historical tsunami deposits
- Early detection of earthquake and tsunami signals using remote sensing and other techniques.

3.9.2 The Central and State Governments will proactively support application oriented research and development activities to address current challenges, offer solutions, and develop new techniques for tsunami safety. Education will be more meaningful only if the new knowledge is applied to address tsunami risk and actual tsunami events are studied to integrate lessons learnt. State Governments will depute multidisciplinary teams for post-tsunami field investigations, document the lessons and disseminate the same to technical and general audiences within the state. The MoES will oversee the conduct of this effort in a systematic manner.

3.9.3 Scenario analysis and simulation modelling are extremely useful for undertaking long-term DM programmes and for strengthening tsunami preparedness, mitigation and response efforts. Risk assessment and scenario projections require data on the existing built environment, infrastructure, and economic activities. The non-availability of such data can otherwise lead to assumption based scenarios. The MoES will encourage the development of standardised methods for tsunami risk assessment and scenario development, support

studies to collect the data and compile knowledge, develop state-of-the-art reports, and evolve a procedure for undertaking pilot projects in risk assessment and scenario analysis.

3.9.4 Even though these Guidelines recommend tsunami strengthening to be undertaken only for a select number of fragile lifeline structures, there are a large number of structures in the country that need to be strengthened. Detailed assessment of tsunami hazard to the structure and foundation and the benefits of strengthening will be carried out before deciding to strengthen these structures.

3.9.5 Studies will be undertaken to evolve a shelf of architectural designs and structural design calculations and drawings of temporary and intermediate shelters that can be constructed in tsunami vulnerable coastal zones regions of the country keeping in mind the weather and the functional needs of the people. This information shelf will be kept in the public domain for use by all concerned. Appropriate locations will be identified for constructing temporary and intermediate shelters in the event of a tsunami.

3.9.6 The knowledge of past tsunami disasters are very useful in the determination of tsunami hazard in the country. The available information on run-up areas due to various tsunamis will be catalogued and digitally mapped on large-scale maps such as those prepared for the Vulnerability Atlas of India. The Ministry of Housing and Poverty Alleviation, in consultation with various knowledge institutions, shall develop suitable large-scale digital maps indicating the tsunami hazard on the basis of past tsunami disasters.

3.9.7 The knowledge of tsunami risk is very poor in the country due to the long intervals between such disasters and poor documentation of past tsunami disasters. Therefore, the entire coastline should be categorised on the basis of likely tsunami run up, and the hazard map should be produced according to this information. In the initial phase, the tsunami hazard assessment should be carried out using existing information and simulation techniques to provide the first-level hazard map. More detailed hazard assessment on large-scale maps should be carried out for urban areas and those regions that are identified with highest risk based on the first-level assessment.

3.9.8 The MoES and other relevant Ministries shall carry out an annual review of the status of tsunami research and development and develop a strategic plan for tsunami research in the country.

3.10 Documentation and Creation of Maps and Databases

3.10.1 MoES, through it's nodal institutions, will prepare and distribute manuals and tsunami hazard zonation maps to the public through SDMAs and concerned Ministries & Departments of the Government of India, to create awareness on tsunami risk and vulnerability among the coastal communities, State administrative authorities and other stakeholders in the coastal districts. Documentaries on tsunami risk and vulnerability, tsunami preparedness and emergency response will be prepared and the media will be encouraged to telecast the same to create

greater awareness on risk reduction. The information provided should cater to different age groups and knowledge levels. Development of portals, websites and its popularisation among the various stakeholders will be carried out by Ministries and Departments of the Government of India concerned. The results of the tsunami propagation models with different tsunamigenic sources and intensities can also be posted on these portals and websites and the limitations indicated so that the coastal communities understand the nature of likely tsunami inundation.

3.10.2 The vulnerability maps on cadastral scale, already prepared in the multi-institutional projects funded by DST, will be updated and such maps will be displayed in public places like schools, community centres, hospitals, various Government offices, etc. Similarly, the list of coastal villages with potentiality of tsunami inundation based on numerical modelling of propagation will be placed in the public domain so that the coastal communities can prepare themselves in the event of any sudden outbreak of a tsunami.

3.10.3 SDMAs will prepare information materials on coastal hazards at State level drawing on the expertise of the academia and various State Departments including Health, Police, Fire and Emergency Services, Revenue administration, Fisheries, Geology and Mining, etc. Workshops to discuss the preparedness and response strategies will be organised in each coastal district by the concerned DDMA and the deficiencies in response, if any, will be assessed through mock drills. The roles and responsibilities of the officers from various departments in the event of a likely tsunami will be well defined, based on the discussions during such workshops. These roles and responsibilities and Standard Operating Procedures will also be incorporated in the DM plans prepared at the district and village levels. Technical documents will be prepared and synthesized involving specialists from academia, State administration and coastal communities. Information Centres for Coastal Natural Hazards will be established in the tsunami-prone States in selected Universities to build repositories of technical information. The rural knowledge centres or Common Service Centres which have been set up in the coastal villages will also provide information on preparedness, mitigation and emergency response measures to be carried out in the coastal areas. Setting up community radio will be encouraged for creating greater public awareness on tsunami risk and vulnerability among the coastal communities.

3.10.4 The MoES will facilitate the preparation of films, manuals and other resource materials targeting various stakeholders to inculcate a culture of safety against tsunamis. State Governments will make available tsunami safety related materials in multiple formats, so that different groups of stakeholders can gather the information relevant to them. State Governments/SDMAs will set up websites and portals to disseminate all tsunami safety related information to stakeholders. This information will include specific details on the tsunami risk and vulnerability of the states, tsunami management basics and tsunami risk mitigation for the safety of the seafront, coastal natural resources and built environment.

3.10.5 The implementation of these Guidelines requires participation of a wide spectrum of professionals. The NIDM and knowledge institutions like the IITs, NITs, Central Research Laboratories of different Ministries

and other professional bodies will create and maintain a directory of technical professionals with expertise in tsunami risk mitigation in India with their bio-data and make this directory of professionals available to the SDMAs and ATIs.

3.11 Public Awareness

3.11.1 Comprehensive public awareness campaigns will be developed and launched at the national, state and district levels, especially in high risk areas for familiarisation with the tsunami warning dissemination mechanism and responsibilities of various stakeholder groups. SDMAs/DDMAs will conduct regular public awareness campaigns for familiarising communities in coastal areas with the tsunami early warning mechanisms through workshops, drills and exercises, screening of video films, distribution of information resources, posters etc. Handbooks and instructional materials, in vernacular languages, will be prepared by SDMAs for creating greater awareness among the communities on tsunami risk and vulnerability.

3.11.2 One of the most challenging tasks in improving the preparedness and mitigation for tsunami is the sensitisation of all stakeholders to the prevalent tsunami risk and educating and encouraging them to participate in strengthening tsunami preparedness and mitigation efforts. If the coastal communities recognise the importance of incorporating tsunami safety measures in the construction of residential buildings, tremendous gains can be achieved in tsunami mitigation. State Governments/SDMAs will, in collaboration with nodal agencies and other key stakeholders, make special efforts to mobilise communities to carry out tsunami mitigation efforts. Electronic and print media will also be used to help create greater public awareness on tsunami risk and vulnerability and on structural and non-structural risk reduction measures. Knowledge institutions such as the IITs and National Institutes of Technology (NITs) and national research laboratories will play a major role in producing these materials for the tsunami-prone SDMAs.

3.11.3 A comprehensive public awareness campaign will be developed and implemented on the safe practices to be followed before, during and after a tsunami. State Governments and knowledge institutions will, in collaboration with professional bodies of engineers, architects and urban planners, initiate programmes to sensitise their members on the importance of undertaking tsunami-safe zoning, planning, design, and construction practices. The contents and structure of training programmes will be reviewed and revised from time to time, factoring in the lessons learnt from the evaluation of the earlier programmes. The professional associations of engineers, architects, builders and contractors will undertake campaigns to sensitise their members on the risk and vulnerability to tsunami in various coastal regions of the country and to impress upon them the need to ensure the incorporation of tsunami-safe features in the construction of buildings and structures in tsunami-prone areas.

3.11.4 State Governments and SDMAs in collaboration with their SEMCs, HSCs and non-governmental organisations (NGOs) will organise awareness programmes for specific target groups of stakeholders on various aspects of tsunami management. These stakeholders will include elected representatives and civil servants, members of local administration authorities and others like

school administrators, members of management boards of educational institutions and hospitals, school children, representatives of the corporate sector, media, etc.

3.11.5 The corporate sector plays a very important role after a disaster by providing resources, relief supplies and equipment. The corporate sector will be encouraged to take proactive role during the mitigation and preparedness phase. They will be encouraged to sensitize their employees and also to develop suitable business continuity plans to ensure disruption-free operation following disasters. As a part of corporate social responsibility, the corporate sectors operating in coastal areas will be encouraged to support public awareness campaigns on tsunami risk and preparedness among vulnerable coastal communities near their locations.

3.11.6 Natural hazards cannot be prevented and hence, awareness on risk reduction and preparedness in the event of tsunami and other coastal Hazards as well as methods of mitigation in local level during the golden hour before the Government machinery steps in, should be carried out through mock exercises and drills from Primary school level to College and University education, especially in coastal areas. Steps have already been taken to include natural hazards in the educational curriculum but it should be a continuing process. Illustrated education materials with information on tsunami dynamics and the damage inflicted in different zones in the form of text books have to be prepared at different education levels for distribution among students. Posters in local vernacular languages or more appropriately colloquial languages without scientific jargons should be displayed in locations frequented by the community. Information on tsunami and other natural hazards should be part of the local language textbooks rather than confining them only to the science subject textbooks, as learning in local vernacular languages will be more effective in communicating the messages to the disaster-prone communities.

3.11.7 Tsunami warning can sometimes be a false alarm due to the complex dynamics of the tsunami, as it is based on the earthquake parameters determined by preliminary analysis of the seismic data immediately after the event. Precise estimation of earthquake and tsunami parameters are possible only after a detailed study of the seismographs established all over the world by different agencies and actual field study by conducting high resolution bathymetric surveys. The tsunami modelling hence fails to estimate the run-up parameters accurately if there is a gross difference between the initial estimate and ground reality. The general public need to be made aware of these complexities and in the event of a false alarm, they should acknowledge the tsunami risk and treat it as an opportunity to test the preparedness of all stakeholder groups. Proper awareness on the intricacies of EWS has to be created through public awareness campaigns and the general public should not panic when an alert is issued. This will enable INCOIS to issue warnings even if there is a remote possibility of a tsunami so that the coastal communities can review their preparedness levels.

3.11.8 Tsunami warning drills have to be periodically conducted and school children in the coastal areas right from elementary school level need to be made aware of safe evacuation procedures. If such drills are conducted every year among children and youth, it will enable the younger generation to be alert when such a calamity actually strikes the coast. It will also

make them understand the mistakes made during the drills so that they can improve their preparedness. It is also advisable to assess the evacuation routes in schools and in public places like hospitals and community centres in vulnerable zones.

3.11.9 Effective steps should be undertaken to provide shelters taking into consideration the population of each coastal village and town. Tourist and Pilgrim centres in particular should also be assessed and the shelters should be designed to cope up with sudden rush to such shelters during emergencies. It is necessary that a public address system is established in vulnerable areas to disseminate the alert and warning messages. Shops, hotels, lodging houses, etc., are often built very close to the shore and the people may not have any knowledge of the coastal hazards and hence their safety may be threatened. Shore watchers should be employed in places where people congregate in large numbers and people should not be allowed to be in the sea immediately after the alert or warning notification is issued. Fishermen should also be prevented from going into the sea after the alert or warning notification is issued.

3.11.10 The increased vulnerability of the coastal areas due to exponential growth of population and establishment of industries and tourist centres necessitates not only education on coastal hazards but also the need for imparting training in preparedness and risk reduction to the stakeholders in the event of a calamity. Institutes, Universities and Colleges should be encouraged to initiate studies related to Natural Hazards and coastal hazards in particular so as to form a multidisciplinary working group comprising dedicated faculty members. The expertise gained by such groups should be used to inform the general public. Multipurpose newsletters or bulletins for creating awareness on natural hazards among the general public should be published by such working groups.

3.11.11 The Training Institutions will be coordinated by the National Institute of Disaster Management (NIDM). Training programmes for State and Local Administration personnel including Fire and Rescue and Police personal, as well as representatives of Self Help Groups, NCC, NSS and other youth groups will be conducted by NIDM and the Administrative Training Institutes (ATIs) of the State Governments. The training modules will include geo-scientific aspects of the coastal hazards with particular reference to tsunami, their causes and effects using appropriate case studies.

3.11.12 Public awareness campaigns will be initiated at the national, state and district levels in high-risk areas for wide dissemination of information on tsunami risk reduction through structural and non-structural strengthening measures among all stakeholders and to develop professional human resources for tsunami-resilient strengthening. Case studies documenting the process of vulnerability assessment will be prepared and disseminated for creating greater public awareness among professionals and critical stakeholders. Risk reduction against tsunami can be achieved by applying currently available national and international knowledge on strengthening; imbibing available national and international knowledge and customising the same; and finally, generating new applied knowledge to address the problems specific to India. Significant and maximum gains can be achieved by conducting rigorous research and

development activities for innovation of new knowledge and techniques and adaptation of available knowledge to the Indian context.

3.11.13 State Governments, SDMAs and professional bodies will organise knowledge sharing workshops to disseminate the methodology and important experiences of protecting seafront, coastal natural resources and lifeline structures against tsunami to the professional community. State Governments will carry out structural safety audit of all bridges, flyovers, critical lifeline buildings and high-priority buildings in the coastal vicinity, and undertake phase-wise strengthening of those critical lifeline structures which will be found to be structurally vulnerable to tsunami. They will also support private agencies to develop their capacity in conducting evaluation and strengthening of existing privately owned structures.

3.12 Education on Tsunamis

3.12.1 NDMA has initiated the efforts in collaboration with nodal agencies like the UGC, AICTE, MCI, ICAR, etc. to include DM in the educational curricula. A Committee has been set up by MHRD with representatives of such nodal agencies and NDMA to examine the scope for revising the curricula. ICAR has already included DM in the curricula for agriculture. State Governments must endeavour to strengthen tsunami education by incorporating the best available technical and non-technical inputs on tsunami safety in educational curricula. Tsunami education will address the multifaceted aspects of tsunami management, especially preparedness, mitigation and response efforts. In this regard, case histories of actual tsunamis will be used as valuable inputs for tsunami education.

3.12.2 The development of high-quality education materials, textbooks, field training and the improvement of the quality of teaching at all levels will be given due emphasis. Education and training programmes will be designed, with greater attention on developing the capacity and skills of trainers and trained teachers. Appropriately designed science and technology courses will be introduced to orient all target groups including school teachers and health professionals in the subject. The Government of India and State Governments will encourage knowledge institutions to undertake research, teaching and training, which will further contribute to improving tsunami education in India.

3.12.3 Disaster related curricula considering tsunami hazard have already been introduced in Class VIII, IX and X levels in the Central Board of Secondary Education (CBSE) schools. Other school boards will develop similar content in their curriculum. State Governments and SDMAs will, in collaboration with their boards of intermediate education, ensure that the subject of disaster safety and disaster preparedness (including tsunami) is introduced at the intermediate education level (Class XI and XII or, their equivalents), as well as at the degree level in the non-technical disciplines. Universities and autonomous institutes will introduce DM (which will include tsunami management) in various educational programmes.

3.12.4 Industrial Training Institutes (ITIs), polytechnics and Universities in the states will develop adequate technical expertise on the various subjects related to DM. State Governments will introduce a five year quality improvement programme for teachers and professionals engaged in teaching the subjects related to tsunami (namely earth science,

architecture, ocean engineering and earthquake engineering). The ongoing and recently concluded technical education programmes for college teachers, viz., the Quality Improvement Programme (QIP); the National Programme for Earthquake Engineering Education (NPEEE) supported by the Ministry of Human Resource Development (MHRD), GoI; the National Programme for Capacity Building of Architects in Earthquake Risk Management (NPCBAERM); and the National Programme for Capacity Building of Engineers in Earthquake Risk Management (NPCBEERM) supported by the MHA, GoI, will be further strengthened through the National earthquake Risk Mitigation Project (NERMP) and expanded to address the gap between the requirement and availability of quality teachers conversant with tsunami-safe design and construction. All such training programmes will incorporate testing and certification of trainees.

3.12.5 The subject of disaster medicine covers aspects like trauma care, epidemic control, emergency medical care by paramedics and emergency medical technicians, and telemedicine. DM related aspects of medical education will receive detailed treatment at the undergraduate level, so that graduating doctors are able to handle emergencies with a better understanding of the issues involved. MoES will, in consultation with the Medical Council of India (MCI), University Grants Commission (UGC), and other related agencies, facilitate the introduction of subjects related to DM, in the undergraduate medical curriculum.

3.12.6 MHRD, GoI, through the NPEEE, has already initiated a number of short and medium-term activities related to capacity building of teachers of architecture and engineering and conducted a number of short-term training programmes for teachers. The teachers who have participated in such courses will be nominated for advanced training and considered to be eligible for admission to post-graduate and doctoral degree programmes at premier national institutes. Such trained personnel will be used as trainers for training the other professionals.

3.12.7 The curricula of IITs, NITs, engineering and architecture colleges, ITIs, polytechnics and universities will be suitably modified to incorporate tsunami-safe design and construction techniques. MoES will facilitate this process in collaboration with MHRD, GoI; the All India Council for Technical Education (AICTE); the Council of Architecture (CoA); and the Institution of Engineers (India), to incorporate tsunami-safe design and construction.

3.12.8 All architecture, planning and engineering graduates will be equipped with the requisite knowledge of tsunami-safe planning, design and construction requirements. The focus will be on improving the knowledge and skill set of human resources; reviewing and revising the curricula; strengthening the facilities; and institutionalising appropriate capacity building mechanisms to ensure tsunami safety. The mainstreaming of tsunami management in development planning will be supplemented with the development of the requisite infrastructure in technical and professional institutions, improved laboratories and libraries in knowledge institutions and R&D institutions. These measures will enable them to undertake research, execute pilot projects, and develop resource materials and technical documents for education, sensitisation and training programmes. The DM plans prepared by Central Ministries and Departments and State Governments will address these requirements in detail.

3.12.9 Centres of public interest such as museums and planetariums will be used for the dissemination of information on tsunami risk mitigation to the public and other stakeholders. MoES, in collaboration with SDMAs, will ensure that a few museums of highest standards that are devoted to natural disasters will be set up in various parts of the country as part of the efforts in creating greater public awareness on tsunami risk and vulnerability.

3.12.10 Steps have already been taken to give special thrust to Natural Hazards in the curriculum at school and College level by several States. The syllabi of the courses should be updated and strengthened periodically for effective creation of awareness. The role of School and College teachers in accomplishing the mission is of great importance and should be done by conducting periodic workshops, contact programmes and distribution of newsletters or bulletins.

3.13 Training and Capacity Building of Professionals

3.13.1 For the prompt and efficient warning and dissemination and feedback the institutions concerned need to be strengthened, as tsunami is relatively a new disaster being faced by the country. Unlike earthquakes, the tsunami impact is mainly confined to the coastal areas having infrequent characteristics. However, there are other hazards such as cyclones, storm surges, tidal impacts, etc which frequent the coast regularly. Hence, it would be efficient to couple tsunami related warnings to the frequently occurring hazards. For this reason strengthening of all those institutions and systems dealing with the coastal hazards will be more prudent.

3.13.2 In order to increase the thrust towards tsunami education in India, the leading institutes and universities identified by MoES shall create dedicated chaired positions for faculty members working in the area of earthquake and tsunami related education and research. Such institutions will also offer the services of such experienced faculty members to participate in the activities specified in the Guidelines.

3.13.3 NIDM at the national level and the ATIs at the state level have been tasked to train administrative personnel from all central Ministries and departments and State Governments in DM. In accordance with these Guidelines, the NIDM will evolve an action plan, in collaboration with the ATIs and other technical institutions, to offer a comprehensive curriculum related to tsunami management, in the form of training modules for the various target groups and initiate the design, development and delivery of the same at the earliest. Training of the Trainers to impart knowledge related to tsunami mitigation measures should be undertaken by the State Governments with the help of IITs, NITs, and other research organisations.

3.13.4 The emergency managers responsible for issuing of tsunami warnings and for responding to tsunami warning require specialised training. Special training programmes incorporating the best global practices will be developed and regular training programmes, including mock exercises and drills, will be imparted for the emergency managers at the national, state and local levels.

3.13.5 Training of artisans in the construction sector in specialized skills is a critical step in ensuring proper quality control in construction

of all structures in tsunami-risk areas. Both in-class training and practice based hands-on training will be undertaken for the artisans involved in different trades including masons, bar benders, welders, carpenters, plumbers and electricians. Such training programmes will be offered to large number of diploma or ITI certificate holders who are involved at the civil engineering project sites. The State Governments will also evolve a formal framework for the certification of artisans and adopt a two year certification cycle. One of such formal frameworks could be adding a minimum 40 per cent of total artisans as trained artisans every year since inception of any government construction project by contractors, developers and builders. The contractors, developers and builders, at their own expense, would enrol the artisans in local training institutes run by building centres, NGO and other local organizations to add on minimum requirement of trained masons into their projects. Further, local ITIs and Polytechnics could act as certifying agencies for such trained masons. The respective State Governments/UT administrations should work out such modalities as per their local requirement. Model course modules and training materials in vernacular languages and certification modalities should be made available to training institutes and certifying institutes respectively.

3.13.6 The National Institutes of Technical Teachers' Training and Research (NITTTR), state ATIs, National Institute of Construction Management and Research (NICMAR), Construction Federation of India (CFI), Builders Association of India (BAI), and other national bodies will contribute to the national effort to build the requisite number of trained personnel to address tsunami safety in India. They will undertake a campaign of `Training the Trainers' amongst artisans, teachers and practicing professionals in order to meet the gaps in human resource requirement.

3.13.7 MoES shall assign the studies to scientific and technical institutions to carry out the survey and document the effects of tsunamis so as to learn about the nature and impact of the phenomenon and to make recommendations on the need for further research, planning and preparedness. Such studies shall recommend the modalities to conduct post-tsunami field reconnaissance investigations, and the standards for the observations, measurements, and assessments, so as to properly collect the data in a consistent and timely manner. Studies are needed to be carried out to record the nature and extent of damage and also the possible cause of damage, pressure created by water waves, buoyancy, impact of debris, record the contamination due to hazardous materials, oil spillage, leakage of chemicals etc., distinguish earthquake damage from the tsunami damage and draw post tsunami survey questionnaire, etc.

3.13.8 The capacity building is required at all levels such as Research and Development (R & D) including monitoring and modelling, communication systems, etc. An indicative list of institutions and individual officers to be involved are:

- INCOIS, NIOT, ICMAM and IMD of MoES
- Indian Institutes of Technology (IITs), Chennai, Hyderabad & Kharagpur / University of Madras, Anna University & other coastal universities
- Centre for Earth Science Studies, Thiruvananthapuram

- Bhabha Atomic Research Centre
- State Disaster Management Authorities / CDM Faculty in Institutes
- State Relief Commissioners, Department of Disaster Management, State Government
- Coastal District Collectorates

3.13.9 NIDM will, in consultation with reputed knowledge institutions, develop comprehensive programmes for creating trainers from among trained faculty members of engineering and architecture colleges and professionals. State Governments and SDMAs will identify potential trainers to develop training programmes at basic, intermediate and advanced levels. These training programmes will be pilot tested, critically evaluated, upgraded, documented, and peer reviewed. Training modules will be developed and continuously upgraded based on the evaluation and feedback from participants.

3.13.10 In the first phase of training, all government architects and engineers, especially in the ULBs and PRIs of each state prone to tsunami risk will undergo training programmes in tsunami-safe design and construction. In particular, the design directorates, if any, in the state departments will ensure that they have architects and engineers with background in tsunami-safe design and construction. Those who have undergone the `Training the Trainers' programme will be responsible for training artisans and practicing professionals through the network of professional societies. A timetable will be drawn up for these training programmes to give architects and engineers the opportunity to upgrade their skills in the required areas. Minimum acceptable standards of safety, as enumerated in the BIS codes, will be disseminated through professional organisations and the training requirements will be integrated with the licensing criteria.

3.13.11 The target groups for capacity development will include elected representatives and government officials, professionals in visual and print media, urban planners, infrastructure development experts, engineers, architects and builders, NGOs, Community Based Organisations (CBOs), social activists, social scientists, schoolteachers, and schoolchildren. Specially designed public awareness programmes will be developed for addressing the needs of physically handicapped and mentally challenged people, women and the elderly.

3.14 Tsunami Preparedness for Far-field and Local Tsunamis

3.14.1 In order to be prepared to protect life and property in the event of a tsunami, it is required to prepare a vulnerability map of the coastal area of the country. To this end, it is necessary to assess the hazard and the fragility of various structures and installations in the coastal area. Evaluation of hazard involves estimation of the run up height of the tsunami wave and estimation of the depth and the extent of inundation. Similarly, evaluation of fragility involves determination of the likelihood of failure of various structures and installations in the coastal area in the event of a tsunami. Social vulnerability mapping done in response to tsunami disasters is quite closely related to such issues.

3.14.2 The disaster preparedness and emergency response capabilities of the island territories in India needs to be augmented adequately.

The island states must have their own coping capacities and adequate capabilities to respond to any emergency, without waiting for assistance from the Central Government. They must set up the State Disaster Response Force (SDRF) from their existing police force and train these SDRF personnel with the help of master trainers from NDRF. The medical facilities in the island territories will also be adequately strengthened and the possibilities of deploying medical ships or medical boats to remote islands will be explored by the health administration. The availability of floating jetties and strengthening of refuelling capabilities in various air strips in Andaman and Nicobar islands will be explored. Wherever necessary, the existing resources of the Coast Guards, Indian Navy, Pawan Hans helicopters and Indian Air Force will also be utilised by the administration of the island territories to meet emergency requirements with the approval of the Central Government.

3.14.3 The following measures will help the the coastal population to prepare themselves for a tsunami :

i. Look for the alert or warning message regarding tsunami, either in local newspapers, radio or television.

ii. Observe the animals in the house for any unusual behaviour patterns as chained or tied animals may show signs of restlessness and agitation in case they feel an impending natural disaster.

iii. Keep disaster supply kits [comprising of all essential items such as medicines, drinking water, food items etc] for survival for a few days

iv. Inform all the household members (who might have gone to their work place) about the message and finalize the evacuation plans.

v. Look for the evacuation routes and possibly reach the destinations (tsunami shelters constructed on the elevated grounds) within a reasonable time.

vi. In case the time available between the announcement about the event and its actual occurrence is sufficiently large, plan for protecting the cattle and other household loose objects.

vii. If the coastal inhabitants reside in a tsunami risk area, they should be aware of the following in advance.

   a. Locations of nearest tsunami shelter, their distance and escape route from the residence to tsunami shelters, mode of travel (preferably by bicycle or moped). Residents of the village must be aware of the tsunami shelter to which they belong and this information must be pasted at the door of the panchayat office.

   b. Know about the ground elevation of the house, street and the area. Look for evacuation orders which normally would be based on these elevations.

   c. Conduct mock exercises and drills frequently to practice on evacuation with the disaster

supply kit. This would enable the public to estimate the time required for evacuation.

d. Discuss with insurance agents and explore the possibility of insuring the lives and property in high-risk areas prone to the occurrence of a tsunami.

e. Get educated on the experience by others about past tsunamis, in case of possibility of a tsunami.

f. Keep valuables and important documents in plastic pouches in safe custody to save them from getting spoiled due to tsunamigenic sea water inundation.

viii. Education in schools, colleges and other institutions regarding tsunami must be made a part of curriculum.

ix. Each coastal village should have its own "Village Disaster Management Task Force" members who would

a. frequently organize meetings to impart knowledge about tsunami,

b. play a role in dissemination of the information on "tsunami alert" received either from the DDMA or any other responsible body.

c. Train the villagers for quick evacuation and organize their stay in the tsunami shelters.

d. Have members drawn from the panchayats, doctors and other volunteers.

x. Know the "Sign Boards" erected in the coastal regions indicating the vulnerable areas, escape routes for the people, details about the capacity of tsunami shelters, and the tsunami shelter to which they belong in the event of a sudden occurrence.

xi. Posters/wall paintings in public places on the beach as well as away from the beach including museums, railway stations, cinema theatres on actions to be taken in case of tsunami warning.

xii. Regionally convenient annual tsunami awareness events may be observed at local community levels. This kind of regional programmes are essential to identify like-minded people and to re-induct fresh youth into the community awareness programmes to mitigate the effects of tsunami disasters in the long run.

3.15 Medical Preparedness

Medical preparedness from tsunami risk will focus on likely injuries, outbreak of diseases and other post tsunami public health problems including psycho-social trauma. Tsunami specific modules will earmark the healthcare facilities, roles of local medical professionals, mechanism for prevention of post-tsunami epidemics of zootomic and water-borne diseases in the area, community professionals trained in psychosocial care and medical support linkages with other districts away from the coastline. It will also address the need for surveillance and for planning and rehearsing tsunami preparedness through mock exercises.

The Medical Preparedness Plan will address the need to create greater awareness

in all medical teams and the medical community at large with regard to frequent type of injuries, illness and other health problems caused by tsunamis. Trained Medical First Responders (MFRs) will be identified in advance to be deployed for administering first-aid and resuscitation measures, at the incident site and during transportation of casualties. In addition to MFRs of the National Disaster Response Force (NDRF), DM plans at all levels will identify medical and paramedical staff to supplement manpower resources at district and state levels. All members of the medical and paramedical teams will carry out regular exercises based on the Standard Operating Procedures (SOPs) laid down by the respective DMAs as part of their DM plan.

A uniform casualty profile of tsunami injuries will be created and a system of triage to classify casualties will be institutionalised so that the treatment can effectively be facilitated by the medical authorities concerned. This plan will include inventory of hospitals and their telephone numbers, availability of ambulances, doctors, anaesthetists, specialists, paramedical staff, sources of public and private sector medical resources, and commonly needed medical supplies and medical stores, blood banks, heli-ambulances and floating hospitals, etc., for easy accessibility. SOPs for medical evacuation, transport of victims and treatment of the injured will also be included.

All public health facilities will develop their own DM plans, with the scope for enhancing their surge capacity in the event of a tsunami. Training exercises and mock exercises and drills will be carried out regularly by doctors as well as paramedical staff. The medical preparedness plans will also include the identification of trained trauma and psycho-social care teams including nursing and paramedical staff. In the coastal areas vulnerable to tsunami, mobile hospitals and Quick Reaction Medical Teams (QRMTs) will be developed as a part of the health-care delivery system of the states to manage patients with minor injuries at the incident site. The Accident Relief Medical Vans (ARMVs) of the Railways will also be deployed to provide immediate emergency medical services in the event of a tsunami disaster.

3.16 Preparation of Disaster Management Plans

3.16.1 Comprehensive DM plans will be prepared at the national, state and district levels. At the national level, the DM plan will focus, inter alia, on various aspects of tsunami management, including preparedness, mitigation and response. These plans will clearly identify the roles of key stakeholders for each level of disaster and also include assessments of their own response capacity. More details on the preparation of DM Plans are given in Chapter 7 on Ensuring Implementation of the Guidelines through the process of preparation of plans at various levels.

3.16.2 Once the DM Plans have been prepared, the SDMAs and DDMAs will monitor the implementation of these Plans to ensure that the various activities are carried out as specified in the Plans.

4 Structural Mitigation Measures

4.1 Mainstreaming DM in Developmental Planning

4.1.1 The Department of Expenditure, Ministry of Finance, GoI, in consultation with NDMA and the Planning Commission, issued O.M. No. 37 (4)/ PF-II/2003 dated 19th June 2009 revising the Expenditure Finance Committee (EFC) and Detailed Project Report (DPR) formats to include DM concerns while submitting proposals for financial sanctions for various plan schemes or non-plan proposals. These revised formats also include a provision for self-certification by the officials submitting the proposals stating that the disaster risk and vulnerability of the area where the new infrastructure or facility is being established has been assessed and appropriate measures have been incorporated to ensure the disaster-resilience of the proposed project from multiple hazards to which the area is vulnerable.

4.1.2 The Ministry or Department of the GoI or the State Government which submits the proposal for plan schemes have to ensure that the physical and regulatory measures that must necessarily be taken based on design and engineering or technology to prevent or mitigate the effect of such disasters have been incorporated within the proposed financial allocation being sought. The appropriate engineering and non-engineering options for risk treatments to the multi-hazard context will have to be incorporated in the proposal for mainstreaming DM concerns in developmental planning at the National, State and District levels.

4.2 Need for New Standards for Protection of Structures against Tsunami

4.2.1 There is a need to identify tsunami-resilient construction practices and ensure their strict compliance. Several premier research institutes of the country particularly a few IITs and SERC have carried out research studies on cyclone-resistant designs and construction of disaster-resilient structures. Along similar lines, there is an urgent need to carry out research studies on tsunami-resistant construction practices for the tsunami-prone coastal areas.

4.2.2 BIS has initiated a draft standard entitled "Criteria for Tsunami-Resistant Design of Structures", which is currently being reviewed.

BIS will ensure that the Draft Standards entitled "Criteria for Tsunami-Resistant Design of Structures" are finalised on priority and disseminated widely. BIS will also develop other necessary standards for the safety of natural habitats against tsunami and storm surge. BIS will also periodically review the standards and codes prepared by them and wherever

necessary, ensure that these standards and codes are revised and updated regularly and placed in the public domain.

4.3 Shelters for Storm Surges and Tsunamis

4.3.1 On receiving a Tsunami Warning, evacuation of the population would be required by the local authority. Safe evacuation will be carried out to cyclone- cum-tsunami shelters along the coast. In recent years, Multi-purpose cyclone- cum-tsunami shelters have been designed and are being constructed in storm surge prone areas. Such multi-purpose shelters can be used as schools, community halls, places of worship and other social gathering places.

4.3.2 Cyclone-cum-tsunami shelters should be designed in such a way that they address multi-purpose uses. Such multi-purpose uses will ensure that such structures do not fall into disuse when there is no threat of cyclones or tsunamis. This would ensure their proper maintenance by the community itself. Cyclone-cum-tsunami shelters should be so designed so as to take care of the livestock of the communities, wherever possible, while protecting the local people.

4.4 Institutionalisation of Design and Construction for Tsunami Safety

4.4.1 It is necessary that the tsunami risk and vulnerability of the coastal areas is taken into consideration while designing buildings and other structures in tsunami and cyclone-prone coastal areas. In the design of public infrastructure like roads, schools, hospitals, multi-purpose shelters etc., prevailing risk and vulnerability has to be kept in mind. In tsunami-prone areas, the DDMAs will ensure that a bank of designs of temporary shelters, intermediate shelters and disaster-resilient houses shall be prepared, with the flexibility to use traditional and local knowledge, coping capacities and locally available shelter materials.

4.5 Tsunami Mitigation Measures

4.5.1 Coastal villages can be safeguarded from the impact of tsunami by adopting soft solutions and by educating the villagers to follow simple precautionary measures. The details are as follows.

i. Construction of large scale submerged sand barriers in water depths of about 6 to 8 meters.

ii. Developing sand dunes along the coast with sea weeds or shrubs or casuarinas trees for stabilization of the sand dunes.

iii. Raising the ground level (above the design water level) with natural beach sand so as to rehabilitate the entire coastal village.

iv. Development of coastal forest (green belt) by planting casuarinas or coconut trees along the coastline to cover minimum of about 500m width of the beach.

v. Periodical dredging of the inlets and associated water bodies so as to absorb the influx during Tsunami.

vi. Construction of submerged dykes (one or two rows along the stretch of the coast) so as to decrease the impact due to the incoming tsunami.

vii. Adopting natural beach nourishment to create steep beach face.

viii. Positioning stationary platforms in the backwaters for evacuating the public during tsunami.

ix. Creation of sandy ramps at close intervals all along the coast.

x. Vertical evacuation structures in all harbours.

xi. Construction of inland dykes to safeguard vital installations.

xii. Construction of concrete defence structures to protect installations of national importance stationed on the coast.

xiii. Construction of elevated hutments supported on piles or hardened podiums to allow tsunami run-up to escape beneath the structure.

xiv. Construction of bypass compound walls to steer the flow (during run-up) away from the buildings in the case of vulnerable buildings in coastal areas. Proper hydraulic design of the bypass wall is needed to take care of the run-down too. This procedure would reduce the flow velocity during run-up of a Tsunami.

xv. Construction of Tsunami shelters (supported by circular RCC columns) on a raised ground (3m above the ground level) in high tsunami-risk villages. This structure shall have 4 floors with the ground floor meant for passage of flow during Tsunami, 1st floor for housing about 500 people, including a provision shop capable of supplying provisions for three days and other basic amenities, 2nd floor for hospital and 3rd floor reserved for the water tank (with a capacity of 60,000 gallons for three days). This Tsunami shelter should be operational throughout the year with the 1st floor utilised as a school and 2nd floor for hospital during non-Tsunami period. This would ensure that the facility is maintained to meet any eventuality. These shelters shall not be located more than 500m. from the two neighbouring villages.

xvi. Establishment of mangrove plantations (as a coastal defence against Tsunami) for communities residing along the estuaries.

xvii. keeping the village area free from debris (for example discarded construction material, automobiles and other similar loose materials) as they may have adverse impact during run-up or run-down associated with Tsunami.

xviii. Construction of seawall (comprising of a stack of rubble) may be tried, in exceptional cases, in conjunction with natural bio-shields, subject to the topography and bathymetry. Reinforced concrete Tsunami gates, Tsunami break-waters, deflection walls, Tsunami river gates in river mouths, etc. can be planned as in Japan, instead of rubble stack. However, in areas which are vulnerable to storm surge, special efforts may be made to ensure that natural bio-shields like mangrove plantations (in estuaries) and shelterbelts (plantations along coastal belts) are initiated to reduce the

devastating impact of storm surges by acting as an effective windshield to protect the coastal communities.

4.5.2 During the Indian Ocean Tsunami of December 2004, the damage to port and harbour structures was observed to be much severe than that in the other structures away from the coast. These structures were subjected to ground shaking due to earthquake and wave action due to tsunami. These structures are founded generally on soft ground with more than one type of foundation system in a structure. Ground subsidence and liquefaction has been commonly observed and was one of the major reasons of common damage. Favourable conditions for corrosion exist near the sea and damage has been observed to be more at corroded locations. The earthquake also exposes the deficiencies caused by faulty design and construction.

The recommended design solutions against various observed tsunami effects, as given in the tables below, can be helpful in the new design and construction of structures.

Table 4.1
Phenomenon of Inundation

Effect	Design Solution
Flooded basement	• Choose sites at higher elevations
Flooding of lower floors	• Raise the buildings above flood elevation/ Stilted type construction
Flooding of mechanical, electrical, communication system and equipment	• Do not stack or install vital material or equipments on floors or basement lying below tsunami inundation level
Damage to building materials and contents	• Protect hazardous material storage facility located in tsunami prone areas
Contamination of affected areas with water borne pollutants	• Locate mechanical systems & equipments at higher locations in the building • Use corrosion resistant concrete & steel for the affected portions of the building.
Hydrostatic forces (Pressure on walls by variation in water depth on opposite sides	• Elevate buildings above flood level. • Provide adequate openings to allow water to reach equal heights inside & outside of buildings. • Design for static water pressure on walls. • Consider suction tensions on walls under receding waters.
Buoyancy floatation or uplift forces caused by buoyancy	• Elevate building to avoid flooding. • Anchor building to foundation to prevent floatation
Saturation of soil causing slope instability and/or loss of bearing capacity	• Evaluate bearing capacity & shear strength of soil that support building foundation and embankment slopes under condition of saturation. • Avoid slopes or setbacks from slope that may be destabilized when inundated.

Table 4.2
Phenomenon of Currents, Wave breaks & bore

Effect	Design Solution
Hydrodynamic forces (pushing forces on the front face of the building and drag caused by flow around the building	• Elevate building to avoid flooding • Design for dynamic water forces on walls & building elements • Anchor building to foundation.
Debris Impact	• Elevate building to avoid flooding. • Design for Impact loads.
Scour	• Use deeper foundation (piles or piers). • Protect against scour and erosion around foundation by providing appropriate aprons.

Table 4.3
Phenomenon of Drawdown

Effect	Design Solution
Embankment instability	• Design water front slopes, walls & buttresses to resist saturated soils without water in front • Provide adequate drainage.
Scour	• Design for scour & erosion of soil around foundation & piles.

Table 4.4
Phenomenon of Fire

Effect	Design Solution
Waterborne flammable materials and ignition increase in buildings	• Use fire resistant materials • Locate flammable materials storage outside of high - hazard areas.

Table 4.5
Phenomenon of Large Floating Body Impact

Effect	Design Solution
Wooden poles from roof etc.	• Can design the masonry walls for the impact of the object with some velocity of water 2-10m/s
Katamarans	• Keep a minimum distance of residences where there are many katamarans used, For important shelter structures on shore this impact can be accounted in structural design.
Large fishing trawlers, Tugs, Boats	• Submerged sea-bed anchoring system can be designed and constructed to avoid them being carried in Tsunami.

	This will be double purpose since self destruction of itself and its impact on residents / houses are avoided. • Alternatively avoid the habitats close to (within 500m) such fishing jetties/ river mouths, or harbours. • Bridge decks in these areas, with simply supported ends, need to be checked for such lateral impact forces of huge boats and of tsunami water.

4.6 Specific Design Principles for Tsunami

In addition to the above, following specific design principles may be adopted for tsunami.

Know the tsunami risk at the site

- Distance from the sea
- Elevation above mean sea level
- Height of high tide above m. s. l.
- Maximum run-up of the tsunami above the site elevation
- Depth and speed of the tsunami wave for design purposes.

Avoid new construction developments in tsunami Run-up areas or take adequate precautions to protect such structures

- Role of land use Planning :
  - Local Context
  - Understanding Trade offs
  - Review and update existing Safety elements
  - Review and update existing Land Use Elements
  - Review and update existing Zoning, and other regulations
- Land use Planning Strategies

Site Planning Strategies to reduce Tsunami Risk

- Avoiding the impact of tsunami by building on high ground - necessary for vital installations.
- Slowing the tsunami wave by frictional techniques - forests, ditches, slopes and berms
- Deflecting the tsunami away by using angled walls - suitable for important installations or Fishermen habitat
- Brute resistance through stiffened strong structural design - costly buildings
- High rise buildings with open ground storey, designed for wave forces - Hotels, offices etc
- Stilted buildings for various uses.

Tsunami Resistant Buildings - New Developments

- Locally applicable Tsunami Hazard Information on Design Intensities
- Performance Objectives
- Mandatory use of building Codes - Design Criteria
- Safety under Multi-hazard environment
- Qualified Engineers and Architects -

knowledge about Earthquake, Wind and Tsunami resistant planning and design

- Ensure quality construction
- All common buildings cannot be designed for Tsunami water hydrodynamic loads, and other heavy impact loads.

Protection of existing buildings and infrastructure - Assessment, Retrofit, Protection measures

- Inventory of existing assets
- Assessment of Vulnerability and deficiencies to be taken care of through retrofitting
- Methods of retrofitting and use in design
- External protection methods from the onslaught of tsunami

Special Precautions in locating and designing infrastructure and critical facilities

- Considerations in relocating and redevelopment of infrastructure
- Considerations in relocating and redevelopment of critical facilities such as lifeline buildings (health, education, community etc.).

Planning for Evacuation

- Vertical evacuation - High rise buildings, special shelters such as Tsunami towers, route sign boards with solar powered lighting, Shelters, and artificial sand dunes
- Horizontal evacuation - Locating high grounds, building high enough mounds
- Awareness about evacuation areas and routes
- Evacuation Planning is an important part of Tsunami planning which requires awareness among residents about evacuation routes and areas. Horizontal evacuation includes provision of high ground, manmade mounds, open space on natural mounds, etc. and vertical evacuation requires proper connectivity between middle and higher floors, etc. Similarly Tsunami Management Plan and various safety measures may be spelt out in advance if jetties, airports, helipads and landing grounds are damaged.
- The use of GIS and aerial photography are necessary for mapping and these maps may be made available to local administration for urban planning on 1:1000 scales having contour interval of 1-2 m.

Planning for Rescue and Relief

- Role of District Disaster Management Authorities (DDMAs)
- Role of Armed forces/Ministry of Defence in these tasks.

Development of Design Criteria

Basis of Design Criteria

Considering the multi-hazard proneness of the coastal districts, the design criteria will have to cover the following aspects:

1. Design wind velocity under cyclone condition.
2. Effective wind pressure near sea coast.
3. Height of storm surge with concurrent tide level.

Tsunami effects: Height & velocity of Tsunami wave, Hydrostatic water pressure, Debris Impact, Wave break impact.

4. Earthquake effects - Design seismic co-efficient
5. Fire safety
6. Flood inundation & flood flow (velocity of flow).

Building aspects: Shape, Size & Height of building, Use importance of the building, On stilts or without stilts, The roof to act as shelter, hence flat (in that case design live load for the roofs); Choice of building material and construction technology; Durability of the building (design life), Thermal comfort.

Use Importance of the Buildings

1. Ordinary (housing, storage)
2. Important (hospital, school, fire station, power house, substation, telephone exchange, VIP residence etc.)
3. Very important installations, cyclone/ tsunami shelters

Performance Level Desired

1. Minimum - Non-collapse though structurally damaged.
2. Safe - Damaged but without significant structural damage.
3. Operational - Capable of avoiding/ resisting all expected hazards & forces.

Table 4.6
General Design Values/Factors for Coastal States/UTs

	Housing	Important Buildings	Cyclone shelter or very important Installation
Wind speed	IS: 875(3)	IS: 875(3)	65 m/s
Factor k1 for k2 Pressure k3	1.0 1.05 1.00	1.08 1.05 1.00	1.08 1.05 1.00
Seismic coefficient IS:1893 (1)	I=1.0, R as per code	I=1.5, R as per code	I=1.5, R as per code
Storm Surge	As per Vulnerability Atlas of India, 1997, riding over maximum astronomical tide level		
Fire safety	1.5 hr rating	2 hr rating	≥ 2 hr rating
Flood safety	Plinth height at recorded high flood level or for		
	10 yr flood	50 yr flood	100 yr flood
	Or Use plinth height of 60 - 120 cm above ground level & needed stilts		

RCC Design Criteria for All Coastal Areas

Concrete (Exposed to coastal Environment, taken as 'severe')

(i) Plain: - Min M20, Cement: min 250 kg/ m3, Max. water cement ratio 0.5

(ii) RCC: - Min M30, Cement: min 320 kg/ m3, Max. water cement ratio 0.45Max. Aggregate 20 mm

(iii) Reinforcement: TMT - HCR (High Corrosion Resistant steel bars)
Fe 415 for up to 2 storeys and Fe 500 for frames in taller buildings

(iv) Min. Cover to HCR Reinforcement Slabs: 20 mm, Beam: 30 mm, Column: 40 mm

(v) HCB (Hollow Concrete Blocks): - To be cast using M 20 concrete with fly ash.

(vi) Reinforcement TMT - HCR Fe 415 bars, concrete filling M 20 grade.

4.7 Protecting Seafronts and Lifeline Structures

4.7.1 India has a very long coast line that is susceptible to the action of tsunami. Most of the coastal structures are not designed to withstand the force of a tsunami, and are potentially vulnerable to collapse in the event of a tsunami unless wave forces are reduced through mitigation measures. Mitigation measures can reduce the effect of tsunami wave impact on structures but do not reduce the effects of inundation. Though collapse-proof structures can be constructed, the contents of these structures and the occupants cannot be protected from the effects of tsunami inundation. Therefore, some critical lifeline structures such as hospitals should be located outside the inundation areas.

4.7.2 Strengthening of seafront (through plantations and coastal constructions) provides the most effective mitigation measure against tsunami and should be carried out along the most vulnerable stretches of the coast.

4.7.3 As it is not feasible or financially viable to strengthen all the existing structures, these Guidelines recommend carrying out the structural safety audit and strengthening of select critical lifeline structures and high priority buildings. Such selection will be based on considerations such as the degree of risk, the potential loss of life and the estimated financial implications for each structure, especially in high-risk areas, i.e., those coastal regions vulnerable to high tsunami run-up. While these Guidelines indicate below an illustrative list of such buildings and structures at below table 4.7, the State Governments/SDMAs will, in consultation with knowledge institutions such as IITs and NITs and Hazard Safety Cells (HSCs), review their existing built environment, and prepare such lists.

Table 4.7
An Illustrative Priority list of Buildings for Protection Against Tsunami

• Buildings of national importance like Raj Bhavans, Legislatures, High Courts, State Secretariats, Historical Monuments, Museums, Heritage Buildings, Strategic Assets and Vital installations such as power plants, and water works located in coastal districts.

• Lifeline buildings, structures and critical facilities like Schools, Colleges and Academic Institutions; Hospitals and Health facilities, Tertiary Care Centre and all hospitals designated as major hospitals in coastal districts.
• Public utility structures like reservoirs and dams; bridges and flyovers; ports and harbours; airports, railway stations and bus station complexes in coastal districts.
• Important buildings that ensure governance and business continuity like offices of the District Collector and Superintendent of Police and buildings of financial institutions in coastal districts
• Multi-storeyed buildings with five or more floors in residential apartments, office and commercial complexes in coastal districts.

Notes; 1. The responsibility to identify and prioritise these structures will rest with respective state governments.
2. Additional lists of buildings and structures to be retrofitted can be prepared, after completion of the first phase of retrofitting of prioritized buildings and structures, based on the experience gained, by respective state governments in selected coastal districts.

4.7.4 While drawing up the priority list for structures, a cluster approach will be followed for selecting various types of critical lifeline structures including breakwaters for ports and harbours and various categories of building types (RCC, stone masonry, adobe, brick and mortar, etc.) in adjoining districts to encourage mutual consultations, demonstrations and possible replication in other districts. Thus, some lifeline structures such as primary schools, primary health centres, panchayat offices, post offices and Block Development Offices may be selected in potential tsunami run-up areas to study their ability to withstand tsunami forces. Where feasible, select priority lifeline structures will be strengthened. The strengthening will provide valuable demonstration of their efficacy. The State Governments/SDMAs will take up selected critical lifeline structures in some of these high-risk areas as pilot projects in a phased manner. Other critical lifeline structures should be considered for relocation away from the vulnerable areas.

4.7.5 Protection is required not only for the structures of buildings (including their foundations) but also for their non-structural components like building finishes and contents. The non-structural building elements include the stairways, doors, windows, chimney, lighting fixures, heating ducts and pipes, wall cladding and false ceilings. The "building contents" includes all of those items that users bring into a building into a building; furniture, appliances, electronic equipments, coolers, and air-conditioners, stored items, and so forth. When a building is totally collapsed or damaged, everything is crushed and lost. Bust some the deaths, many or most of the injuries, a large proportion of economic damage, destruction and disruption associated with earthquakes are caused by "non-structural" building elements that break, fall or slide. Therefore, securing the contents and elements of the building from overturn or slide during a Tsunami requires due attention. Protection of non-structural elements and contents in tsunami run-up is a specialised technical task which needs to be handled by engineers proficient in this field, as any routine alteration, repair or maintenance carried out in a structure may not always guarantee an improvement in its safety, and may in fact, increase its vulnerability.

4.7.6 Various types of protective measures to safeguard the seafront against tsunami are very effective tool in tsunami risk mitigation since it directly reduces the intensity of tsunami force on the seafront natural resources and structures. Due attention shall be given to various natural and artificial seafront strengthening and risk mitigation measures. In coastal regions vulnerable to high run-up, the feasibility of providing protective structures to strengthen the seafront shall be given very high priority. Strengthening of the seafront and risk mitigation measures may obviate the necessity of additional structural mitigation measures for buildings and other structures and will cause least inconvenience to the affected population.

4.7.7 Different types of coastal protective measures can be adopted to minimise the intensity of tsunami generated force. Though the different options for coastal protective measures have been given above, careful assessment on the type of protection to be adopted for a given stretch of the coast is a must. For example, mangroves which can withstand moderate wave climate can be cultivated along the estuaries. They act as a buffer zone while a tsunami passes over thus reducing the tsunami induced force on the coastal belt. For the wide sandy coast, it is advisable to develop sand dunes with shrubs grown on the sand dunes to stabilise them. In case of narrow sandy coast, artificial nourishment techniques can be adopted to raise the level of beach such that the foreshore slope of the beach front becomes steep. Maintenance of lagoons free from sediment deposition at the inlet and in the main water body would prove beneficial as the influx during tsunami can find its resting place. Development of long shoals (parallel to the coast) in the near-shore region by dumping useful portion of the dredged sand either from harbours or river channels would be another option to protect the coast from the impact of tsunami. Development of green belt on the sand spits would suit the coastal belt with backwaters running parallel to the coast.

DDMAs will explore the inclusion of coastal protection measures to be eligible for schemes like National Rural Employment Guarantee Scheme, as they will meet the employment generation objective and provide the much needed protection to the fragile coastal areas.

4.8 Prioritisation of Structures

4.8.1 All Central Ministries and Departments and State Governments will draw up phased programmes for strengthening and/or possible relocation of selected existing structures duly prioritised and implement them through ULBs and PRIs. Like all new construction, any structural modification of existing buildings will also require compliance with safety regulations against tsunami.

4.8.2 The initial focus for structural safety audit and strengthening will be on government and public buildings. The necessary capacity for carrying out similar assessments for private buildings will also be developed through suitable capacity development efforts among the professionals in the private sector. The nodal agencies will make available the details of technical guidance for carrying out structural safety audit of lifeline structures and their strengthening in public domain for the use of the general public and professionals in the private sector.

4.8.3 The seafront shall be prioritised for strengthening on the basis of the vulnerability of the natural resources, lifeline structures and

the local community. The necessary capacity for carrying out vulnerability assessment shall be developed through suitable capacity development efforts among the various government agencies.

4.9 Structural Safety Audit of Seafront, Coastal Natural Resources and Critical Lifeline Structures

4.9.1 The tsunami risk profile can be quantified only after the vulnerability of the coastal region and building inventory in a geographic area is compiled. Assessment techniques may be used to determine the vulnerability of all buildings, in the order of priority decided by the State Governments/ SDMAs, in consultation with IITs, NITs and HSCs. Two levels of vulnerability assessment can be carried out for buildings, namely Rapid Visual Screening (RVS) and Detailed Vulnerability Assessment (DVA).The former is a quick estimation with visual but technical information of structures to determine whether the structure is considered to be vulnerable or not. Once the RVS identifies a structure to be vulnerable, then that structure is subjected to a detailed assessment for a quantitative evaluation of its vulnerability. For structures other than buildings, DVAs are normally carried out. A DVA consists of evaluating the structural systems that resist the tsunami loads, as well as assessing non-structural elements like the contents, finishes and elements that do not contribute in resisting any tsunami load of the structure.

4.9.2 RVS procedures for assessment of safety against tsunami need to be developed for all types of building systems in India, e.g., brick and stone masonry buildings, RCC frame buildings with masonry infill, etc. Detailed studies will be conducted at the national level to develop a consensus on the methodology that should be undertaken for RVS of buildings in India as a part of vulnerability assessment. The vulnerability assessment exercise will be carried out at every 10 years to monitor the modification to the vulnerability profile of the built environment.

4.9.3 At the national, state and district levels, issues such as lack of knowledge on cost estimates for strengthening each type of structure, the types of tools required for undertaking modifications/enhancements of existing structural elements, the time required to complete the strengthening of a particular size and type of building and the proficiency required by the artisans for strengthening and their requisite capacity building., will be addressed in collaboration with the nodal agencies and professional bodies concerned. Organisations like IITs, National Building Construction Corporation Ltd. (NBCC), Building Material Technology Promotion Council (BMTPC), Central Building Research Institute (CBRI), Structural Engineering Research Centre, Chennai (SERC), the Institution of Engineers (India) (IE[I]), Construction Industry Development Council (CIDC), Construction Federation of India (CFI), and the National Academy of Construction (NAC), will be associated to develop road maps for creating the required manpower, tools and construction management system to implement the structural strengthening challenge in India. In consultation with these agencies, a standardised procedure for vulnerability assessment will be prepared at the national level to clarify the process and issues involved in the

strengthening of each type of structure as per national standards.

4.9.4 The vulnerability assessment of the seafront and coastal natural resources can be carried out only on the basis of reliable large-scale maps. Assessment techniques may be used to determine the vulnerability of structures of seafront in the order of priority decided by the State Governments/SDMAs, in consultation with their SEMCs and HSCs. Multi-level vulnerability assessment can be carried out for these structures. The quick and approximate assessment of tsunami amplification can be carried out by using available terrain and bathymetry data. In densely populated regions or in other areas, as required by the State Governments/SDMAs, more detailed assessment can be carried out later using large-scale maps.

4.10 Protecting and Strengthening

4.10.1 The Government shall launch targeted programs similar to GoI-UNDP supported UEVRP for tsunami safety. Under this program, protecting and strengthening of some fragile seafront, coastal natural resources and lifeline structures will be undertaken through pilot projects in a phased manner. The prioritisation of the cities will be based on the degree of tsunami hazard, population size, level of vulnerability of the building/structure, importance of the lifeline structure and coastal natural resources, and the speed with which the states can undertake these initiatives. The cities are to be identified based on these criteria for strengthening of selected lifeline structures. In the first priority, metropolitan cities and major townships in high tsunami run-up regions may be taken up.

4.10.2 Similar efforts will be carried out in other high-risk coastal towns and cities in a selective manner by initially starting with the capacity development of professionals to carry out these tasks. Accomplishing protection of the existing built environment requires a systematic and sustained effort by carrying out several activities in each of the towns and cities. These activities are:

- Developing an inventory of the coastal natural resources and the existing built environment.
- Assessing the vulnerability of the above environment.
- Prioritising of the environment based on its vulnerability.
- Developing protection and strengthening measures.
- Undertaking construction work to strengthen vulnerable areas and structures.

4.10.3 Whereas protection and strengthening of the critical and lifeline structures will be carried out on priority, other structures will be insured against losses during future tsunamis. Insurance companies will be encouraged to introduce innovative insurance schemes in moderate and high tsunami-risk coastal zones in consultation with the ULBs and respective Disaster Management Authorities (DMAs).

4.10.4 State Governments/SDMAs will initiate efforts to compile GIS databases and develop a GIS data bank consisting of GIS maps for all urban areas, indicating vulnerable seafront and natural resources, all critical structures and infrastructures. These maps will be used in DM planning, and for effective coordination for

response, relief and rehabilitation activities during and after a disaster.

4.10.5 State Governments/SDMAs will develop appropriate mechanisms, in consultation with their SEMCs and HSCs, to review and ensure structural safety of existing public buildings in accordance with the latest norms during any significant alterations or additions to them. Similar process should also be carried out in respect of defence works/ structures in high tsunami-risk areas.

4.10.6 The Government of India will utilize the national rural employment guarantee scheme and other similar schemes for using local manpower for constructing and strengthening of protective seafront structures. The local community will be given the responsibility of maintenance and upkeep of these structures to ensure community participation in disaster management efforts.

4.10.7 The GoI can generate new incentives to promote through policy decisions and to allow tax-holidays, to private/Corporate sector for their contributions to build and operate priority structures such as Tsunami-towers/platforms/ shelters, as part of their CSR (corporate social responsibilities) activities.

4.10.8 As far as possible, local authorities will discourage the construction of structures in areas vulnerable to high tsunami risk. In case of construction of structures in areas prone to sea erosion and high risk of tsunami, the professionals involved in the design and construction of such structures will be made aware of the tsunami risk and vulnerability in such areas.

MoES, in co-operation with other concerned Ministries and Departments of GoI and State Governments and other specialised agencies, will initiate the efforts for developing a Data Base of Tsunami Risk and Vulnerability in the coastal areas of the country, with information on trends of storm surge, high tides, local bathymetry, etc. for providing value-added information to the general public for protecting the investments proposed to be undertaken through construction of structures on the sea front. Once the Data Base is developed, MoES will make it available in the public domain, wherever possible, or accessible to the professionals who are involved in the construction of such structures after confirming the authenticity of such requests.

5 Regulation and Enforcement of Techno-Legal Regime

5.1 Land Use

5.1.1 Coastal areas are vulnerable to coastal hazards such as cyclone and tsunami. Coastal land use should be so designed so as to incur minimal losses to life and property due to these events. Natural mangroves and bio shields should be protected and grown so as to provide a natural defence against Tsunami waves. By developing bio shields at coastlines, tsunami prone land use can be re-designated as tsunami resistant.

5.1.2 Existing zoning and other regulations need to be reviewed and updated in the context of Tsunami. The change of land use in coastal Zones should not be permitted without approval of the authority implementing Coastal Zone Management Plan. It is desirable to take up development at a safe distance from the coast line. New location of settlements may be sited above 10 m contour levels or 3 m above the high tide line, whichever is higher. Location of new settlements should be planned on the basis of thorough analysis of distance from the sea, elevation above MSL, height of high tide line, maximum run up of tsunami, expected depth and speed of tsunami waves, etc. The process of urban renewal and urban extension should be used to plan and zone new land uses in order to limit or prevent potential disasters. Open Spaces such as agricultural lands, parks, other forms of open space, etc. can be used as places to gather and take shelter during tsunami. For preparing the proposals for development in disaster prone area, Town Planning Departments/Development Authorities concerned should take specialized advice from Geological Survey of India, Metrological department and other concerned nearby academic institutions having expertise in earthquake engineering, structural engineering, etc. Coastal buildings need to be designed to withstand tsunami wave pressures. At present, no tsunami code exists. There is urgent need to frame Tsunami Resistant Design Code and include it in local building bye laws. The code may fulfil various safety measures under multi hazard environment. Effective implementation of building bye-laws is to be ensured by the State Governments and ULBs in construction of buildings and local infrastructure should be strengthened to make them resistant from tsunami and cyclonic sea surge.

5.1.3 Coastal ecology should be protected and strengthened while coastal habitats should be planned in such a way so as to remain in low hazard zone. Mangrove plantations should be conserved and protected. Casuarinas, bamboo and other shelterbelt plantations need to be encouraged in the coastal areas. The coastal geomorphic features such as beaches, sand dunes etc. should be protected as they act as buffers against the coastal hazards.

5.2 Bio-Shields

5.2.1 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, which also safeguards ecological and livelihood security of fishing and farming communities living in the coastal zone. In addition to mangroves, which grow only in the estuarine environment, there are many other tree species having with socio-economic and ecological importance can reduce the impact of tsunami and cyclonic wind & sea surge. 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 is 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.

5.2.2 While mangrove forests have specific ecological role in the coastal eco-system and source of livelihood for coastal poor, their destruction is wide spread for shorter economic benefits. In the recent times there has been increased ingress to convert them for aquaculture and agriculture. The usage of chemicals/ fertilizers and pollution in the upstream of aquaculture farms become detrimental to the mangrove eco-systems in the vicinity. In general the mangroves are resistant to varied kinds of environmental perturbations and stresses. However, mangrove species are sensitive to excessive siltation 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 to recognize that many of the forces, which detrimentally alter mangroves, have their origin outside the mangrove eco-system. Unless many of these threats are addressed through efficient management and regeneration programmes, the sustainability of mangrove habitats cannot be ensured.

5.3 Options for Efficient Land Use Practices

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. In view of above, following options for best land use practices should be considered.

i) The policies and incentives for afforestation should be such that ecological security and income security are both safeguarded.

ii) Encourage adoption of science-based and traditional, sustainable land use, promote reclamation of wasteland and degraded forestland covering both public and privately owned lands 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) Funding of green belt creation 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 has to be enhanced in the interest of creating life and livelihood security in the coastal zones. Innovative funding mechanisms should also be evolved by levying either a charge or a cess for all development activities on the coastal area which would be pooled to reverse degradation and enhance conservation of green belts. It is also necessary to give some incentives to private land owners and fisherman to adopt sustainable practices.

5.3.1 Based on CRZ and best land use practices, it is necessary to plan for conservation and restoration of mangroves and raising tree shelterbelts extensively in all potential coastal zones. The CRZ Notification, 1991 under the Environmental Protection Act,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 Ministry of Environment & Forest, Botanical Survey of India, Zoological Survey of India, State Governments and some 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.

To bring mangrove regeneration under suitable and secured land use zoning, following actions will be initiated:

i. Set up a Task Force in consultation with states to identify new mangrove areas on priority to enhance the spread of the mangrove areas in various states within 6 months.

ii. Launch the dual mode mangrove plantation programme.

iii. Direct planting of seeds or propagules in the muddy areas (plenty)

iv. 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. Species selection is to be made based on the availability and maturity of planting materials from the locality.

vi. Zonation pattern is to be considered primarily in restoration work.

vii. State governments should 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. Mangroves should be officially classified as forests and mangroves found anywhere should be placed under the control of the state forest departments. The important mangrove areas need to be declared as protected areas if they are not so covered already.

x. A concerted effort needs to be made 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.

5.3.2 Raising coastal shelterbelts to mitigate the adverse impacts of cyclone winds is one of the short-term objectives of the National Afforestation Programme (NAP). However, this is not being taken up effectively. Further, the regeneration of degraded forest and adjoining areas in the coastal zones is not covered under NAP as per the plantation design and guidelines. Hence, following actions will be initiated for effective shelter belt plantation at coast lines.

i. Raising of coastal shelterbelts will be made a mandatory component of the NAP plans by MoEF.

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 the coastal bio-shields for facilitating the implementation.

5.3.3 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 shelterbelt to fight the cyclonic winds and cyclonic & tsunami sea surge requires appropriate strategy, which would be free from such problems and would have practical applicability. Under the Shelterbelt Plantation Programmes along the coast taken up from 1977, to a width of 5 km from the shore was tackled. This 5 km width has been differentiated in to the first 500 m zone or main zone and 500-5000 m zone or support zone.

5.3.4 The Main Zone consists of afforestation with block plantations. The natural conditions prevailing in the main zone are very hostile and are characterized by salinity, poor soils with high pH, low nutrition, poor moisture

retention capacity, inadequate irrigation facilities, subjected to high speed and salt laden winds etc. For effective management of all these difficult areas, the entire main zone of 500m all along the coast has to be stock mapped. Stock maps are to be prepared indicating all types of areas, soils, crops, plantations, etc. The method of treatment to be adopted for shelter belt plantation on a particular piece of land may be decided on the basis of stock map.

5.3.5 A Support zone is aimed at saturating the area with tree crops planting all around the 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 500-5000m. Islands offer unique eco-systems and coastal planning and regulation in their case needs to take into account features such as their geological nature, settlement patterns, volcanic or coral nature of the island, size of the habitations, unique cultures, livelihood patterns, etc. along with adequate environmental safeguards

5.4 Selection of Species and Efforts for Community Involvement

5.4.1 The selection of species has to be done by taking in to consideration factors like bio-diversity, 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 each cyclone and tusnami. Tidal amplitude is an important factor to be considered for species selection and is easily measured by calculating distance between the highest high-tide to 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 main and support zones up to 5000m from the coastline are to be implemented truthfully through Joint Forest Management (JFM) concept and the afforestation through Vana Samrakshana Samitis (VSS) along with accrued monitory benefits. Community involvement and beneficiary oriented nursery programmes are crucial for the regeneration of forest cover and coastal shelterbelt consolidation. This should be encouraged.

5.5 Monitoring Shelterbelt Plantations and Mangrove Regeneration Zones

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

5.5.2 Other Important desired actions for mangrove regeneration and shelter belt plantation with effective zoning regulation are as below:

i. MoEF jointly with state government departments should take leadership and commission a state-wise survey of conserved areas which would be

appropriately designated as community reserves, and have them notified by the respective State Governments for preparation of management plans

ii. Local communities living in and around forest areas are to 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 5000m of coastline by utilizing high resolution remote sensing satellite images from CARTOSAT type satellites may be established to monitor coastal shelterbelt plantations

iv. Establishment of a dedicated IFS sub-cadre for conservation and a training centre for coastal and marine biodiversity conservation and management are necessary

v. An Institutional mechanism to empower Coast Guards to enforce the Wild Life (Protection) Act, 1972, up to 500m of coastal stretches must be considered

5.6 Funding Support for the spread of Mangroves and Shelterbelts

5.6.1 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. The National Afforestation Programme (NAP) was started as a 100% Central Sector Scheme during the X five year plan. NAP is implemented by involving two tier setup namely Forest Development Agency at Forest Division level and Joint Forest Management (JFM) Committee at Village level. On an average, about Rs 250 crores are allocated for NAP during the Plan period covering all states of the country but without any special emphasis on restoration of coastal bio-shields. DDMAs will make special efforts to ensure that employment generation schemes like NREGA will be specially made applicable in tsunami-prone areas for establishing shelter belt plantations and mangrove plantations.

5.7 Techno-Legal Regime for Coastal Zones

5.7.1 The absence of codes and standards for safety against tsunami is one of the major factors responsible for the poor implementation of tsunami-safe construction practices.

Considering the overriding interest of public safety, the BIS will place all Indian Standards related to protection of structures and safety from storm surge and high tides, in the public domain, including the internet for free download, as and when they are issued.

5.7.2 State Governments/SDMAs will, in consultation with their SEMCs and HSCs, establish the necessary techno-legal and techno-financial mechanisms. This is to ensure that all stakeholders like planners, builders, architects, engineers and government departments, responsible for regulation and enforcement adopt tsunami-safe zoning, planning and construction practices and provide for safety in all design and construction activities in such a way that acceptable safety benchmarks against tsunami are satisfied.

5.7.3 The model techno-legal framework prepared by the expert group of Ministry of Home Affairs shall incorporate relevant zoning for tsunami safety, planning, design and construction practices. The modifications to incorporate these provisions will be carried out at the earliest.

5.7.4 All State Governments/SDMAs in tsunami-risk regions will adopt the model techno-legal framework for ensuring compliance of tsunami-safe zoning, planning, design and construction practices in all new constructions. State Governments will update the urban regulations by amending them to incorporate multi-hazard safety requirements. State Governments will review, revise and update the town and country planning Acts, land use and zoning regulations, building bye-laws and DCRs, and this process will be repeated at least once every five years.

5.7.5 The designs of some structures in tsunami-prone regions, randomly selected by the ULBs, will be subjected to detailed technical audit for reviewing the entire design process and detailed design calculations. A procedure will be developed by each State Government/ SDMA for undertaking this third party audit or external compliance review by accredited agencies for ensuring the review of a structural safety audit. In particular, the external compliance review of seafront structures, lifeline buildings and infrastructure in tsunami-prone areas will be undertaken as per the recommendations of the expert group set up by the MHA, GoI.

5.7.6 Rural and semi-urban areas account for most of the total building stock in India. The construction of these structures is presently unregulated and is adding to the number of vulnerable structures. Specific illustrative guidelines will be issued by State Governments for each non-engineered construction type in tsunami-prone areas and demonstrated through the construction of new public buildings in villages. For instance, the buildings of panchayat offices, post offices, primary schools and primary health centres in rural and semi-urban areas will be used as demonstration buildings.

5.7.7 State Governments will develop suitable bye-laws for rural areas where most buildings are non-engineered, keeping in mind the local conditions, and, especially on priority in high-risk areas. State Governments/SDMAs, in consultation with SEMCs, HSCs and Panchayat Raj Institutions will regulate all future constructions near the shore line to provide safety against tsunami.

5.8 Techno-Financial Regime

5.8.1 After a tsunami, the Central and State Governments provide funds for immediate relief and rehabilitation. This process does not adequately cover the requirements for reconstruction of damaged structures, especially those that are privately owned. Expenditure incurred by the GoI in the provision of funds for relief, rehabilitation and reconstruction after disasters is increasing manifold due to the rapidly increasing risk profile of the country. Therefore, effective risk-transfer strategy shall be taken up through introducing innovating risk insurance tools for people. Insurance does not reduce the immediate impacts of disaster, but it gives compensation against losses by covering risk in exchange for a premium payment. People affected by a tsunami benefit from the contributions of the many others who are not affected and thus receive compensation that is greater than their premium payments. Launching of insurance

scheme would also prompt insurance companies to promote tsunami risk mitigation among community. In most countries, risk transfer through insurance has been adopted as a step towards providing adequate compensation for the loss of property caused by disasters. Such a mechanism reduces the financial burden of the government. Risk transfer mechanisms have been found to be fairly successful and hence, the insurance sector will be encouraged to promote such mechanisms in the future. The risk transfer mechanism shall cover not only the privately owned structures, but also government-owned structures and coastal natural habitats.

5.8.2 The Ministry of Finance will develop a national strategy of risk sharing through micro-finance and self-help groups reaching to the most vulnerable communities. The MoF will facilitate the development and design of appropriate mechanisms to ensure the viability and long-term subsistence of these micro-level risk transfer mechanisms.

5.8.3 Financial institutions will consider the compliance of safety against tsunami before offering housing loans including those for construction of industrial, commercial and multi-storied complexes. The construction programmes supported by the GoI and State Governments (like Indira Awas Yojana), and all large-scale housing schemes will be made to comply with design and construction practices for safety against tsunami.

5.8.4 In tsunami-prone coastal areas, the approval and disbursement of funds from banks and other financial institutions to industrial units will also be linked to the compliance with tsunami safety norms by these units. The MoES will coordinate with the relevant bodies for development of suitable techno-financial measures to improve the tsunami safety of the industrial units' corporate groups, Special Economic Zones (SEZs), techno parks etc. located in tsunami-prone regions.

5.8.5 National Disaster Management Guidelines on Techno financial Issues like Risk Sharing, Risk Transfer, Insurance issues will be prepared by NDMA which will deal with techno-financial strategies for addressing various disaster risks.

6 Emergency Tsunami Response

6.1 Tsunami Response Requirement

6.1.1 A coordinated and effective response system would be required for management of tsunami at central, state, district and community levels. For an effective and prompt tsunami response, warning communication and dissemination to all stakeholders is imperative. As soon as the warning is issued, the Tsunami Response Plan will be activated in the concerned areas. Response to early warning would involve safe evacuation of community population with minimal loss to property (living and non-living assets).

6.1.2 Depending on the scale of Tsunami, the run-up height and level of storm surge, the scale of response will be mobilised at community, district, state and national level. Systems will be institutionalised by the Disaster Management Authorities at various levels for coordination between various agencies like Central Government Ministries, Departments, State Governments, district authorities, ULB's, PRI's and other stakeholders for effective tsunami response.

6.2 Emergency Search and Rescue

6.2.1 Past experience in various disaster situations has shown that community is always the first responder in all types of disasters. The local community, before the intervention of the State machinery and specialised search & rescue teams, responds initially and saves a number of lives. Trained and equipped teams consisting of local people will be set up along the coastal areas to respond effectively in the event of tsunami. Periodical induction of freshly trained local youths in these teams is important for fast-response.

6.2.2 Community-level teams will be developed in the coastal districts with basic training in search & rescue. Training modules will be developed for trainers of community level search & rescue teams by NDRF training institutes. On ground, the NDRF Battalions will assist the State Government/district authorities in training communities. They will be further assisted by Civil Defence, Home Guards, Fire Services and NGOs. State Governments will develop procedures for formally recognising and certifying such trained search & rescue team members. State Governments will provide suitable indemnity to the community level team members for their actions in the course of emergency response following an tsunami. Youth organisations such as National Cadet Corps (NCC) and National Service Scheme (NSS) and Nehru Yuva Kendra Sangathan (NYKS) will provide support services to the response teams at the local level under the overall guidance and supervision of the local administration.

6.3 Emergency Relief

6.3.1 Trained Community level teams will assist in planning and setting up emergency shelters, distributing relief among the affected people, identifying missing people, and addressing the needs of education, health care, water supply and sanitation, food etc. of the affected community. Members of these teams will be made aware of the specific requirements of the disaster-affected communities. These teams will also assist the Government in identifying the most vulnerable people who may need special assistance following a Tsunami.

6.3.2 The concerned Indian Navy and Coast Guard forces will extend close cooperation by supporting boats, latest equipments, skilled/ trained man power and other possible assistance to local administration for carrying out rescue and relief activities in the tsunami affected areas.

6.4 Incident Response System

6.4.1 NDMA has prepared the Guidelines on Incident Response System (IRS) in collaboration with all concerned stakeholder groups for streamlining the coordination of response in the event of a sudden occurrence of any disaster. This will be operationalised through Incident Response Teams (IRTs) at appropriate levels for effective coordination of response. All response activities will be undertaken at the local level through a suitably devised IRS, coordinated by the local administration through well-equipped Emergency Operations Centres (EOCs) with appropriate computer hardware, software packages and data bases. State Governments will commission and maintain EOCs at appropriate levels for coordination of human resources, relief supplies and equipment. SOPs for the EOCs will be developed by State Governments and integrated within the framework of the IRS, which will take advantage of modern technologies and tools, such as GIS maps, scenarios and simulation models for effectively responding to disasters. GIS maps available from other sources such as the city planning departments, state space application centres and other such sources, will be compiled considering their potential application after a disaster. State Governments/SDMAs will undertake training of personnel involved in IRS.

6.5 Community-Based Disaster Response

6.5.1 A number of organisations, like NGOs, Self Help groups, Community Based Organisations, youth organizations, women's groups, volunteer agencies, civil defence, home guards, etc. normally volunteer their services in the aftermath of any disaster. State Government/SDMAs and DDMAs will coordinate the allocation of these human resources for performing various response activities. State Governments will work with these agencies to understand and plan their roles in the command chain of the IRS, and incorporate them in the DM Plans.

6.5.2 Large-scale disasters draw overwhelming humanitarian support from different stakeholders. The relief and response activities carried out by such stakeholders will comply with the norms prescribed by the appropriate authorities.

6.5.3 After a Tsunami, accurate information will be provided on the extent of the damage and the details of the response activities through electronic and print media. State Governments will utilise different types of

media, especially print, radio, television and internet, to disseminate timely and accurate information.

6.5.4 Special efforts will be made by the DDMAs to enlist the support of NGOs and humanitarian agencies to ensure that in the event of a sudden occurrence of a tsunami, adequate emphasis will be placed on restoration of livelihoods of the tsunami affected people disrupted by the tsunami. The needs of psycho-social support and trauma care of the tsunami affected people will also be met through special efforts by trained social workers and clinical psychologists.

6.6 Involvement of Corporate Sector

6.6.1 State Governments will facilitate the involvement of the corporate sector in making available their services and resources to the Government during the immediate aftermath of Tsunami. The Corporate sector, as a part of the Corporate Social Responsibility, can initiate appropriate projects in partnership with Government agencies through Public Private Partnership (PPP). Such PPP projects may provide inter alia the services of hospitals, power and telecommunication, relief supplies, search & rescue equipment, transport and logistics for movement of relief supplies to the extent possible and technical services for restoration and reconstruction of damaged infrastructures. For instance, the Construction Federation of India with the support of Hindustan Construction Ltd. has set up the Disaster Response Network (DRN) which can also be associated during response, restoration and recovery phase. State Governments and district authorities will develop appropriate mechanisms to receive and optimally utilise all such assistance. NDMA has also supported the establishment of the Corporate Disaster Resource Network (CDRN) for identifying the critical needs of disaster-affected villages and for facilitating the appropriate corporate responses to meet these needs.

6.7 Specialised Response Teams

6.7.1 The Central Government has set up eight NDRF battalions for providing rapid response to disasters. Two more NDRF battalions have been sanctioned by the Central Government, which will be established at the earliest. All 144 teams of NDRF will be especially equipped and trained in search & rescue operations during a tsunami event. The NDRF battalions are also being provided with communication equipment for establishing last mile connectivity.

6.7.2 The Police play a very important role after a disaster in maintaining law and order, assisting in search & rescue, transportation of the casualties and certification of casualties. The Home Guards, the auxiliary arm of the Police force, shall support the district administration in various disaster response tasks.

6.7.3 Parliament has passed the legislation for amendment of clause (a) of Section 2 of the Civil Defence Act, 1968 relating to definition of "civil defence" so as to bring within its scope the "Disaster" and "Disaster Management" as defined in clauses (d) and (e) of section 2 of the Disaster Management Act, 2005. Further, country's Civil Defence set up is being reoriented to assist in handling Disaster Management. Members of these organisations will be trained in tasks like search & rescue and evacuation, protection of assets in evacuated

areas, and management of relief camps and aid distribution centres, etc.

6.8 Improving Tsunami Response

6.8.1 To augment the capacities of the states, all State Governments will raise, from within their armed police force, adequate strength of personnel for raising of State Disaster Response Force (SDRF) with appropriate disaster response capabilities. In addition, local Police, Fire Services, Home Guards and Civil Defence set ups are being strengthened and upgraded to have adequate capacity to respond effectively to disasters. Deployment of Indian Armed Forces for post-tsunami response work will be resorted only as the last option.

6.8.2 As stated in the National Policy on Disaster Management, experience in major disasters in the last decade has clearly established the need for prepositioning some essential relief reserves at strategic locations, including some for the high altitude areas, as National Disaster Mitigation Reserves. These reserves are intended to augment the resources at the State level for immediate response and made available to the States in case of necessity, and replenished when the initial reserves have been utilised. At the National level, these reserves are expected to meet the needs of 450,000 people affected by disasters, including 150,000 people in high altitude areas. These reserves will be released to the State Governments only in the case of grave disasters by the Central Government on the recommendation of NDMA. The relief supplies in these reserves include tents, tarpaulins, blankets, durries and certain equipment like fogging machines, water pumps, generators, inflatable lights, field latrines, shelters (especially for the hill states), etc.

6.9 Evacuation Plans and Shelters

6.9.1 Inflatable motorised boats, helicopters and search & rescue equipments are required immediately after a tsunami to carry out search and rescue of people trapped in inundated areas, on tree tops and hanging on to structures. State Governments will compile a list of such equipment and identify suppliers of such specialised equipments and enter into Long Term Agreements for their mobilisation and deployment in the event of tsunami. India Disaster Resource Network (IDRN), which is a web-based resource inventory of information on emergency equipment and response personnel available at every district, will be revised and updated frequently. The IRS will also provide a web-based system for monitoring the emergency logistics requirements of disaster-affected villages as well as the flow of emergency relief supplies to the affected villages.

6.9.2 The setting up of relief camps for the people whose houses have been damaged by tsunami or flooded by the storm surge and the provision of basic amenities in such camps involves complex logistics of mobilising relief supplies, tents, water supply and sanitation systems, transport and communication systems, and medical supplies. Immediate restoration of power supply would be essential to carry out relief operations. The DM Plans at the State and District levels will address this issue in detail. An information booth for victims would be established by the district authorities.

6.9.3 In the event of mass casualties, States will develop systems for proper identification of dead bodies, recording the details of victims, and their DNA fingerprinting.

6.10 Emergency Medical Response

6.10.1 Prompt and efficient emergency medical response will be provided by Quick Reaction Medical Teams (QRMTs), Mobile Field Hospitals, Accident Relief Medical Vans (ARMVs) and Heli-ambulances. They will be activated to reach the tsunami-affected areas immediately, along with dressing material, splints, portable X-ray machines, mobile operation theatres, pulse oximeters, resuscitation equipment and life-saving drugs, etc. Resuscitation, triage and medical evacuation of victims who require hospitalisation will be done in accordance with SOPs. A large number of victims may suffer from psycho-social trauma, for which appropriate counselling will be provided.

6.10.2 The medical response plan will integrate all aspects of emergency medical management at the incident site, medical care facilities during transportation and evacuation, adequate ambulance services with defined evacuation routes and other communication linkages and coordination with other identified agencies.

6.10.3 The emergency medical plan will be operationalised immediately on receiving information from the tsunami-affected areas. Hospitals in the affected areas will create a surge capacity for the required number of beds by discharging non-critical patients and mobilise doctors and support staff, additional orthopaedic equipment and supplies at short notice from non-coastal areas. The emergency medical plan will identify the requirement of enhanced manpower, medical stores and the requirement of blood and its components. After a tsunami, information centres will be set up to provide medical response information to the public, relatives of victims and media. The designated hospitals will also identify the surgical teams that can be deployed in the field at short notice and arrange for their transport, medical equipment and supplies. State Governments will coordinate with both government and private hospitals in order to facilitate effective and adequate hospital response after tsunami.

6.10.4 Documentation of medical response provided after a tsunami will be done by a medical administrator. This documentation will be used as feedback for future improvement of the response strategies.

6.11 Role of the Indian Naval Hydrographic Department (INHD) in Response

6.11.1 INHD plays a very significant role, especially during natural disasters that affect the coastal areas. During the devastating Bhuj Earthquake of January 2001 that hit the Gujarat coast in the Gulf of Kutch, two Indian Naval survey ships of INHD carried out urgent surveys of Kandla port channel and their approaches to re-commence the shipping activities in the area. Incidentally, these were also converted into Hospital ships to provide necessary medical logistic support to the earthquake victims and to provide other relief measures. During the Indian Ocean Tsunami of 26th December 2004, seven of the eight survey ships were deployed from Indonesia to Sri Lanka to open their basic sea lines of communication for providing

smooth flow of international aid apart from providing the medical aid. After the tsunami, majority of the areas in Andaman and Nicobar apart from other adjoining areas, had become in-accessible due to large change in bathymetry. These survey ships with 4 boats, an integral helicopter and versatile crew were engaged to urgently re-chart the area and bring out the latest bathymetry information. In addition to use of other state-of-the-art response mechanism, INHD shall also be pressed into action during any future tsunami emergency.

7 Ensuring Implementation

7.1 Preparation of National Disaster Management Plan

7.1.1 The National Executive Committee (NEC) will prepare the National Disaster Management Plan based on the National Policy on Disaster Management (NPDM) and the various disaster-specific Guidelines laid down by NDMA. The National Plan will comprise

i. A National response Plan incorporating the response strategies of all the Central Ministries/Departments and related agencies, covering all hazards. This will be prepared by an Inter-Ministerial Team constituted by the NEC, and

ii. Mitigation and Preparedness Plans prepared by the various Central Ministries and Departments and other concerned agencies covering different disasters specifically.

7.1.2 The National Plan, inter alia, will include various aspects of tsunami management and be approved by the NDMA. The salient activities covered by this Plan will include:

- Preparation of state and district DM plans, with specific reference to the management of tsunami.
- Revision of town planning bye-laws and adoption of model bye-laws.
- Wide dissemination of earthquake and tsunami-safe building codes, the National Building Code 2005, and other safety codes.
- Urban Local Bodies like Municipal Corporations, Municipal Councils as well as PRIs will prepare their DM plans and participate actively in training, development, enforcement of building bye-laws, disaster-resilient building codes and other relevant safety codes and standards, etc.
- Training of trainers in professional and technical institutions.
- Training professionals like engineers, architects, and masons in earthquake and tsunami-safe construction.
- Launching demonstration projects to disseminate earthquake and tsunami-safe techniques.
- Launching public awareness campaigns on tsunami safety and risk reduction and sensitising all stakeholders to tsunami risk mitigation.
- Establishing appropriate mechanisms for compliance review of all construction designs submitted to ULBs.
- Undertaking mandatory technical audits of structural designs of major projects by the respective competent authorities.

- Developing an inventory of the existing built-environment.
- Assessing the tsunami risk and vulnerability of the existing built-environment by carrying out structural safety audits of all critical lifeline structures in coastal areas.
- Developing tsunami safety standards and guidelines for existing critical lifeline structures in coastal areas.
- Assessing the tsunami risk and vulnerability of the existing built-environment by carrying out structural safety audits of all critical lifeline structures in coastal areas.
- Undertaking strengthening and retrofitting of critical lifeline structures, initially as pilot projects and then extending the exercise to the other structures in a phased manner in coastal areas to withstand the effects of tsunami - wave impact and scouring.
- Preparation of DM plans by schools, hospitals, super malls, entertainment multiplexes, etc., and carrying out mock exercises and drills for enhancing preparedness.
- Integration of coastal and tsunami risk into community planning
- Strengthening the EOC network.
- Streamlining the mobilisation of communities, civil society partners, the corporate sector and other stakeholders.
- Preparing community and village-level DM plans, with specific reference to management of tsunamis.
- Carrying out the vulnerability assessment of earthquake and tsunami prone areas and creating an inventory of resources for effective response.
- Introducing tsunami safety education in schools, colleges and universities and conducting mock exercises and drills in these institutions.
- Strengthening tsunami safety research and development in professional technical institutions.
- Preparing documentation on lessons from previous tsunamis, especially the Indian Ocean tsunami of 26 December 2004, and their wide dissemination.
- Developing an appropriate mechanism for licensing and certification of professionals in earthquake and tsunami-safe construction techniques by collaborating with professional bodies.
- Preparing an action plan for the upgradation of the capabilities of the IMD and BIS with clear roadmaps and milestones.
- Developing appropriate risk transfer instruments by collaborating with insurance companies and financial institutions.
- Operationalising the NDRF battalions.
- Operationalising the SDRF battalions in the states.
- Strengthening the medical preparedness for effective tsunami response, etc.
- Enforcement and monitoring of compliance of tsunami-safe building

codes, town planning bye-laws and other safety regulations, and

- Roles and responsibilities of different Ministries and Departments of the Government of India and other concerned nodal agencies in respect of the various measures specified in the Guidelines.

7.2 DM Plans of Central Ministries and Departments

7.2.1 Each Central Ministry/Department will prepare its DM plan which will cover all aspects of the disaster cycle for every disaster, including tsunamis. Every Ministry or Department of the Government of India, if any way concerned to tsunami, will identify the measures in their DM Plans for prevention and mitigation of tsunami in accordance with the National DM Plan and Guidelines. They will integrate the tsunami mitigation measures in their development plans. In relation to preparedness, capacity-building and response to deal with any threatening tsunami situation or tsunami, the Ministries or Departments will define their roles and responsibilities in DM plans. They will also define their present status of roles and responsibilities in dealing tsunami, major gaps therein and measures required for further improvement. The Ministries or Departments will also review and update their plans annually. These plans will clearly indicate the actions to be taken, the allocation of tasks among the various functionaries, the SOPs to be followed, the methodology for carrying out the tasks specified and the timelines for their execution. Mock exercises and drills will be carried out to test the efficacy of the implementation of these plans by various agencies falling within the purview of various Ministries/Departments and other stakeholders at regular intervals. The Ministries or Departments will make provisions for financing the activities identified in their DM Plans in relation to tsunami response, preparedness and mitigation measures. Besides, they will forward a copy of their DM plans to NDMA through Central Government and furnish a status report of implementation to NDMA, as and when required.

7.2.2 DM plans will necessarily address the worst-case scenarios and cover various aspects of management of response, risk, situation, information and communication. Since some disasters may transcend geographic boundaries, these plans will also recognise the importance of effective networking and coordination of different levels of response mechanisms.

7.3 DM Plans of State Governments

7.3.1 NDMA has provided financial assistance to the State Disaster Management Authorities to engage knowledge institutions within their State to prepare DM Plans in collaboration with relevant departments and agencies. All the Coastal States and UTs, while preparing State DM Plan, shall include the vulnerability of different parts of their states/UTs to tsunami and measures to be adopted for prevention, mitigation, capacity building and preparedness to tsunami disaster. The States/UTs will define their roles and responsibilities in DM plans for tackling tsunami disasters. They will also define their present status of roles and responsibilities in dealing tsunami, major gaps therein and measures required for further improvement. The State DM Plan will define the manner in which the mitigation measures shall be integrated with the development plans of the State. The States/UTs will also review and

update their plans annually. Besides, the State DM Plan will make provisions for financing the activities identified in their DM Plans in relation to tsunami response, preparedness and mitigation measures. In addition to preparing their DM plans, State Governments will also encourage the preparation of community preparedness plans to address their own special features and outline the linkages of the various state support systems and the jurisdiction of each of these departments. The GoI had initiated the GoI-UNDP Programme on Disaster Risk Management (DRM) to encourage the development of district, block, taluka and village DM plans, which will be further strengthened through the Disaster Risk Reduction (DRR) Project. The existing plans will be modified, where required, in order to streamline and optimise the tsunami response systems. These DM plans will be widely disseminated among various stakeholders for creating greater public awareness. These plans must indicate responsible office for carrying out specific tasks along with timelines for implementation.

7.3.2 Authorities in charge of education institutions falling in tsunami risk zones will prepare tsunami preparedness plans and conduct mock exercises and drills. Using school buildings as temporary relief camps during disasters disrupts the education of children for long periods. Alternative arrangements for accommodating relief camps will be put in place through various mitigation projects to gradually reduce the dependence on the buildings of educational institutions.

7.3.3 All hospitals of coastal areas will develop their emergency plans, conduct mock exercises and drills and update themselves from time to time with relevant information on tsunami disaster management and preparedness. State Governments/SDMAs will monitor the preparation and testing of these plans. State Governments will ensure that all government offices are able to withstand tsunami, and are fully prepared with DM plans.

7.3.4 The DM plans will incorporate all the features of the EOCs including their establishment and operations.

7.4 DM Plans of Departments of State Governments and UT Administrations

7.4.1 All the Departments of Coastal State Governments and UT Administrations, concerned to tsunami in any way, will identify the measures for prevention and mitigation of tsunami in their DM Plans in accordance with the National and State DM Plans and DM Guidelines. They will integrate the tsunami mitigation measures in their development plans. In relation to preparedness, capacity-building and response to deal with any threatening tsunami situation or tsunami, the Departments will define their roles and responsibilities in DM plans and integrate them with State and National DM Plans. They will also define their present status of roles and responsibilities in dealing tsunami, major gaps therein and measures required for further improvement. The Departments will also review and update their plans annually. State Departments will make provisions for financing the activities identified in their DM Plans in relation to tsunami response, preparedness and mitigation measures. Besides, they will forward a copy of their DM plans to State Disaster Management Authorities (SDMA) through State Government and furnish a status report of implementation to SDMA, as and when required.

7.5 DM Plans of Nodal Agencies

7.5.1 The Indian National Centre for Ocean Information Services (INCOIS) is the national tsunami warning centre and is the nodal agency for monitoring of tsunami in India and provides information based on predictive models through their network of observatories. It will record the occurrence of any tsunami impending to any part of Indian coasts and report the same to various designated functionaries in the GoI and the State Governments.

7.5.2 The IMD maintains a countrywide network of 51 seismological observatories for regional seismic monitoring in India. As most of the tsunamis generate due to earthquakes of greater magnitude, these observatories also provide information on seismic activities to predict tsunami. The IMD is presently in the process of upgrading its network of observatories by adding 20 new stations and upgrading 20 existing stations with state-of-the-art systems. Also, a 20-station telemetry system is planned to be established in the North-East for precise monitoring of seismic activity in the region.

7.5.3 The BIS is the nodal agency for preparing earthquake- and tsunami-safe building codes and other safety related codes. For structures like dams, the responsibility lies with the Central Water Commission (CWC), while for the bridges, it lies with the Indian Roads Congress (IRC). The Indian Standards Committees set up by the BIS have been working on the revision and finalisation of tsunami safe codes. The BIS will ensure finalisation of all pending revisions within the next two years.

7.5.4 The MoES has been set up by the Government of India to bring together the Earth Commission, the IMD, and other key institutions to facilitate effective coordination of the various aspects related to the ocean, meteorology, seismology, marine environment, atmosphere and earth sciences, not specifically allotted to any other Department or Ministry. As the nodal agency for tsunami management, the MoES will prepare their DM plan based on the Guidelines laid down by the NDMA. The various aspects of the DM plans prepared by the other Central Ministries/Departments and State Governments and other stakeholder groups will be included in the DM plan prepared by the MoES, GoI. The MoES will also prepare a comprehensive plan for the upgradation of the capabilities of the IMD with clear roadmap and milestones.

7.6 Implementation of the Tsunami Management Plan

7.6.1 Planning, executing, monitoring and evaluating are four facets of the comprehensive implementation of the Guidelines. If desired, MoES can co-opt a Specialist nominated by NDMA to assist them in the preparation of the Plan. The Tsunami Management Plan prepared by MoES in consultation with coastal states and concerned nodal agencies will be implemented with the support of SDMAs, DDMAs and nodal agencies.

7.7 Financial Resources for Implementation

7.7.1 As mentioned in the Guidelines for Management of Cyclones, 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.

7.7.2 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 Tsunami Management Plan is organised on a priority basis.

7.7.3 The sources of funding for all Tsunami Management Plan related activities will be as follows:

i) Annual Plan/Budget: for mainstreaming Tsunami Management 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.

7.7.4 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 tsunami resistant design and construction practices.

7.7.5 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 Guidelines in accordance with the rules of Govt. of India. 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.

8 Summary of Action Points

The Ministry of Earth Sciences (MoES) as the Nodal Ministry, will prepare a detailed Action Plan for management of tsunami in accordance with these Guidelines with specific tasks, activity targets and time-frames that will also be a part of the National Disaster Management Plan. Besides, following action points will be implemented by concerned line Ministries/ Departments, State Governments/UT Administrations and other agencies:

Chapter-1: The Context

1. Implementation of Integrated Coastal Zone Management (ICZM) Plan:

i. Ministry of Environment & Forest (MoEF) will implement the recommendations of the M.S. Swaminathan Committee Report.

ii. Pilot study taken up jointly by the Survey of India, Centre for Earth Science Studies, Space Applications Centre 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, as per M.S. Swaminathan Committee Report, will be completed at the earliest and MoEF will submit the final report to NDMA..

iii. Demarcation of the vulnerability line, as per M.S. Swaminathan Committee Report, all along the coastal areas of the country, will be completed by MoEF and State Governments.

iv. Based on the vulnerability line demarcation, MoEF will bring Coastal Zone Management Legislation after inviting public suggestions and objections as per Environment (Protection) Act 1986, (EPA).

v. The mapping of the hazard line is one of the components of the World Bank-assisted Integrated Coastal Zone Management Project (ICZMP) which has been approved by the GoI. As a part of this project, it is proposed to establish a National Centre for Sustainable Coastal Management at Chennai and initiate Pilot ICZM projects in Gujarat, Orissa and West Bengal.

vi. All the States and UTs will implement Integrated Coastal Zone Management (ICZM) Plan in its true spirit.

(Para 1.7) (Action: MoEF, State Governments, UT Administrations)

Beyond the recommendations of the Swaminathan Committee Report, the ICZM will make a holistic approach to the sustainability of coastal resources and environment based on

the existing and future local scale vulnerability profile which incorporates the concerns of climate change and sea level rise has to become a part of ICZM. ICZM will associate local panchayati raj institutions and local communities in the management of coastal resources for safeguarding human safety and ecological integrity in the coastal areas. Enhancing the economic well-being of the fishing and farming communities along the shoreline through an integrated bio-shield programme need to be assigned high priority. In the medium term, integrated and ecologically-socially sustainable coastal zone management systems should be put in place jointly by government agencies and coastal communities.

(Para 1.6.2) (Action: MoEF, State Governments, UT Administrations)

Chapter-2: Tsunami Risk Assessment and Vulnerability Analysis

2. Tsunami Vulnerability Assessment

i. The vulnerability assessment of both built and natural environment due to tsunami impact will be developed for shores and harbours by MoES as per these Guidelines.

(Para 2.4) (Action: MoES, State Governments, UT Administrations)

3. Role of the Indian Naval Hydrographic Department (INHD) in Tsunami Risk Assessment

i. Indian Naval Hydrographic Department (INHD) shall regularly provide bathymetry information to authorized agencies for drawing of inundation maps. The Survey of India, National Remote Sensing Centre, INHD and State Remote Sensing Application Centres must provide inputs to the Ministry of Earth Sciences (MoES) for preparing the Disaster Management Plans.

(Para 2.5) (Action: MoES, SOI, NRSC, State and UT Governments)

Chapter-3: Tsunami Warning System

4. Warning System Components and Instruments

i. India Meteorological Department (IMD) will complete implementation of Real Time Seismic Monitoring (RTSM) Network. RTSM will monitor and, report the occurrence of earthquakes capable of generating Tsunamis to INCOIS.

(Para 3.1.2) (Action: MoES, IMD, State Governments, UT Administrations)

ii. The critical gaps in the availability of monitoring instruments like BPRs, tide gauges, surface buoys, etc. to cover the Bay of Bengal, Arabian Sea and the Indian Ocean for close monitoring of tsunamigenic behaviour will be carried out by MoES urgently on priority. The MoES will carry out an assessment of the feasibility of the existing installations to cover the potential tsunami-prone areas and augment the installation of all instruments as per this assessment to ensure that all possible tsunamigenic behaviour patterns are captured as early warning and alert messages through this augmented network.

(Para 3.1.8) (Action: MoES)

iii. The efforts for surveillance of the safety of the critical early warning instrumentation in the Bay of Bengal and the Arabian Sea will be augmented preferably with the specialised aircraft available with National Remote Sensing Centre (NRSC) and where available with Unmanned Aerial Vehicles (UAVs) with the help of Indian Air Force, Indian Navy and Coast Guard patrols to ensure the fail-safe functioning of these critical instruments and their protection from vandalism by fishermen and mariners.

(Para 3.1.10) (Action: NIOT, NHO, DoS and MoD)

iv. The MoES and the nodal institutions like INCOIS, NIOT and IMD will participate in the ongoing multilateral and bilateral cooperation initiatives in sharing information about possible tsunamigenic behaviour with their counterpart nodal agencies in the neighbouring countries through appropriate channels worked out through mutual consultations.

(Para 3.1.11) (Action: MoES)

6. Decision Support System and Standard Operating Procedures

Tsunami Alert, Watch and Advisory Bulletins received at the NEOC, SEOCs and DEOCs will be disseminated through the fastest means to the people in the coastal areas likely to be affected. With receipt of information, respective SDMAs and DDMAs will act as per the stipulations laid out in these Guidelines at para 3.4.4.

(Para 3.4.4) (Action: SDMAs, DDMAs and State Governments and UT Administrations)

7. Tsunami Early Warning Dissemination

i. The National Emergency Communication Plan (NECP) connectivity network will form the backbone architecture for the dissemination of Tsunami Advisory, Watch, Alert and Cancellation Bulletins. The network based on satellite communication links and ISDN public network will link the National Tsunami Early Warning Centre with the NEOCs, the SEOCs, DEOCs, MEOCs and NQRTs. Fail proof and reliable communication links for voice, facsimile, data, FTP, video conferencing, video information dispatch will be provided between all the nodes. In addition to the primary links (Satellite/VSAT between the NEOCs and the SEOCs; ISDN between SEOCs and DEOCS/MEOCs) two back up layers will be provided to ensure redundancy and 100 % availability.

(Para 3.5.1) (Action: MoES, State Governments, UT Administrations)

ii. The NEWC of INCOIS will keep 24 x 7 operations watch and communicate Tsunami Advisory, Watch and Alert Bulletins to local, state, national and international entities as well as media, and the public. The NEWC will be connected and networked with the NEOC, the nerve and decision center for all emergency communication, on the NECP architecture and will incorporate the VPN- DMS communication of ISRO. The NDRF Battalions located in the coastal states will be also treated as primary nodes

for the dissemination of tsunami alert and warning messages.

(Para 3.5.2, 3.5.3, 3.5.4)
(Action: MoES, INCOIS)

8. Roles and Responsibilities in Warning Dissemination

Tsunami / watch warning and information bulletins need to be clearly specified and notified as below:

Institution	Role	Responsibilities
IMD	Seismic Network	Monitoring Earthquake, rainfall, flooding to provide drainage paths
INCOIS	Watch & National Tsunami Warning Centre	Monitor and provide information based on predictive models
MHA	Warning & information bulletins	Issue warning & periodic bulletins
State Relief Commissioner (SRC) / Secretary (DM)	Watch & warning	Issue site specific warning in the State based on the inundation warning and feedback to MHA
District Collectors	Watch & information feed back	Issue site specific warning within the district based on SRC & ground level feed back to SRC
Ports / harbours / coast guard/ marine enforcement and other local public offices	Warning & feed back	Sign boards & announcements. Feed back to District Collector
Police (local)	Warning & feed back	Voice announcements at the site. Feed back to District Collector
Local NGOs and groups	Warning & feed back	Voice announcements at the site
Visual media & radio	Warning & feed back	Direct broadcast and feed back to all
Mobile/SMS/VHF	Warning & feed back	Direct broadcast and feed back to all

8. Role of Media in Warning Dissemination

i. The media will establish and indicate nodal points for receiving Tsunami Warning Bulletins to the respective SDMAs/DDMAs; integrate all regional and local offices of the media elements with the NECP network up to the DEOC level; institutionalise SOPs for transmitting Tsunami Warning Bulletins as received at the nodal points; incorporate measures in the various media channels and processes to ensure priority override for transmitting Tsunami Warning Bulletins at any time; to build capacity for the Media people to ensure that the correct level of warning is made available at the right time. Spreading of rumours should not be permitted,

because these may generate panic and stampede.

(Para 3.7) (Action: State Governments and UT Administrations)

9. Coordination Mechanisms

i. A Coordination Committee comprising of representation from MHA, MoES (IMD, INCOIS), DST, MCIT, MoIB, Prasar Bharti (All India Radio and Doordarshan) constituted under the NDMA, will meet bi annually to review the status, future developments and upgradation of facilities, procedures and systems for Tsunami Early Warning System.

(Para 3.8.1) (Action: MoES, MHA, DST, MoIB, Prasar Bharati)

ii. India will participate in the international effort at improving the quality of preparedness and response by liaising with international organisations, UN agencies and other humanitarian actors and share the best practices in tsunami preparedness and mitigation.

(Para 3.8.2) (Action: MoES, MHA and MEA)

10. Research & Development (R&D) Efforts

i. Tsunami wave propagation in the Indian Ocean is very complex when compared to the Pacific Ocean. The propagation characteristics have to be understood fully and peculiar features specific to the Indian Ocean have to be incorporated in the models in order to achieve high accuracy and reliability in the predictions. Efforts will be given towards R&D as per the suggestions given at para 3.9 in these Guidelines

(Para 3.9) (Action: State Governments, UT Administrations)

11. Documentation and Creation of Maps and Databases

i. MoES will prepare and distribute manuals and zonation maps to the public through SDMAs and concerned Ministries & Departments of the Government of India, to create awareness on tsunami risk and vulnerability among the coastal communities, State administrative authorities and other stakeholders in coastal districts. Documentaries will be prepared and the media will be encouraged to telecast the same to accomplish the goal of risk reduction. The information provided should cater to different age groups and knowledge levels. Development of portals, websites and its popularisation among the various stakeholders will be carried out by Ministries and Departments of the Government of India concerned. The results of the tsunami propagation models with different tsunamigenic sources and intensities can also be posted on these portals and websites and the limitations indicated so that the coastal communities understand the nature of likely tsunami inundation.

ii. The vulnerability maps on cadastral scale, already prepared in the multi-institutional projects funded by DST, will be updated and prepared maps will be displayed in public places like

schools, community centres, hospitals, various Government offices, etc. Similarly, list of coastal villages with potentiality of tsunami inundation based on numerical modelling of propagation will be placed in the public domain so that the coastal communities can prepare themselves in the event of any sudden outbreak of the tsunami.

iii. SDMAs will prepare information material on coastal hazards at State level drawing on the expertise of the academia and various State Departments including Health, Police, Fire and Rescue Department, Revenue administration, Fisheries, Geology and Mining. Workshops to discuss the preparedness and response strategies will be organised in each coastal district and the deficiencies in response, if any will be assessed through mock drills. The roles and responsibilities of the officers from various departments in the event of a likely tsunami will be well defined based on the discussion during such workshops. These roles and responsibilities and Standard Operating Procedure will also be incorporated in the disaster management plans prepared at the district and village levels. Technical documents will be prepared and synthesized involving specialists from academia, State administration and coastal communities. Information Centres for Coastal Natural Hazards will be established to build repositories of technical information. The rural knowledge centres which have been set up in the coastal villages will also provide information on preparedness mitigation and emergency response measures to be carried out in the coastal areas. Setting up community radio will be encouraged and established for creating greater public awareness on tsunami risk and vulnerability among the coastal communities.

(Para 3.10) (Action: MoES, SDMAs, State Governments, UT Administrations)

12. Public Awareness

i. Comprehensive public awareness campaigns will be developed and initiated at the national, state and district levels, especially in high risk areas for familiarisation with the tsunami warning dissemination mechanism, process, practices and procedures and actions by each entity. SDMAs/DDMAs will conduct regular public awareness campaigns for the tsunami early warning mechanisms though workshops, drills and exercises, video films, distribution of ICTs, and publicity material, posters etc. Handbooks and instructional cards, in vernacular and other local language, are to be prepared by states and districts for all villages and communities in the tsunami risk areas and distributed to all. Material and procedures developed at the national level are to be fine tuned and adapted by SDMAs/DDMAs to suit local needs in the coastal areas.

ii. State Governments/SDMAs will, in

collaboration with nodal agencies and other key stakeholders, make special efforts to mobilise communities to carry out tsunami mitigation efforts. At the national level, public awareness materials like brochures, manuals, booklets, action plans, videos, and demonstration kits will be developed for creating public awareness on this subject. Such materials will be fine-tuned by the State Governments/ SDMAs to suit local needs, especially in rural areas. Electronic and print media will also be used to help create greater public awareness of tsunami risk and vulnerability and on structural and non-structural risk reduction measures. Knowledge institutions such as the IITs and National Institutes of Technology (NITs), national research laboratories will play a major role in producing these materials.

iii. State Governments and SDMAs in collaboration with their SEMCs, HSCs and non-governmental organisations (NGOs) will organise awareness programmes for specific target groups of stakeholders on various aspects of tsunami management.

iv. As a part of corporate social responsibility, the corporate sectors operating in coastal areas will be encouraged to support public awareness campaigns on tsunami risk and preparedness among vulnerable coastal communities near their locations.

v. Illustrated education materials with information on tsunami dynamics and the damage inflicted in different zones in the form of text books have to be prepared at different education levels for distribution among students. Posters in local vernacular languages or more appropriately colloquial languages without scientific jargons should be displayed in locations frequented by the community. Information on tsunami and other natural hazards should be part of the local language textbooks rather than confining them only to the science subject textbooks, as learning in local vernacular languages will be more effective in communicating the messages to the disaster-prone communities.

vi. The general public need to be made aware of complexities in inevitable false alarm that may occur sometime. They should acknowledge the tsunami risk and should treat such false alarm as an opportunity to test the preparedness of all stakeholder groups. Proper awareness on the intricacies of EWS has to be created through public awareness campaigns and the general public should not panic when an alert is issued. This will enable INCOIS to issue warnings even if there is a remote possibility of a tsunami so that the coastal communities can review their preparedness levels.

vii. Tsunami warning drills have to be periodically conducted and school children in the coastal areas right from elementary school level need to be made aware of safe evacuation procedures.

viii. Effective steps should be undertaken to provide shelters taking into consideration the population of each coastal village and town. Shore watchers should be employed in places where people congregate in large numbers and people should not be allowed to be in the sea immediately after the alert or warning notification is issued. Fishermen should also be prevented from going into the sea after the alert or warning notification is issued.

ix. The Training Institutions will be coordinated by the National Institute of Disaster Management (NIDM). Training programmes for State and Local Administration personnel including Fire and Rescue and Police personal, as well as representatives of Self Help Groups, NCC, NSS and other youth groups will be conducted by NIDM and the Administrative Training Institutes (ATIs) of the State Governments.

x. State Governments, SDMAs and professional bodies will organise knowledge sharing workshops to disseminate the methodology and important experiences of protecting seafront, coastal natural resources and lifeline structures against tsunami to the professional community. State Governments will carry out structural safety audit of all bridges, flyovers, critical lifeline buildings and high-priority buildings in the coastal vicinity, and undertake phase-wise strengthening of those critical lifeline structures which will be found to be structurally vulnerable to tsunami. They will also support private agencies to develop their capacity in conducting evaluation and strengthening of existing privately owned structures.

(Para 3.11) (Action: State Governments, UT Administrations, SDMAs and DDMAs, ATIs and NIDMA)

13. Education on Tsunamis

i. NDMA has initiated the efforts in collaboration with nodal agencies like the UGC, AICTE, MCI, ICAR, etc. to include DM in the educational curricula. A Committee has been set up by MHRD with representatives of such nodal agencies and NDMA to examine the scope for revising the curricula. ICAR has already included DM in the curricula for agriculture. State Governments must endeavour to strengthen tsunami education by incorporating the best available technical and non-technical inputs on tsunami safety in educational curricula. Tsunami education will address the multifaceted aspects of tsunami management, especially preparedness, mitigation and response efforts. In this regard, case histories of actual tsunamis will be used as valuable inputs for tsunami education.

ii. The development of high-quality education materials, textbooks, field training and the improvement of the quality of teaching at all levels will be given due emphasis. Education and training programmes will be designed, with greater attention on developing the capacity and skills of trainers and

trained teachers. Appropriately designed science and technology courses will be introduced to orient all target groups including school teachers and health professionals in the subject. The central and State Governments will encourage knowledge institutions to undertake research, teaching and training, which will further contribute to improving tsunami education in India.

iii. Disaster related curricula considering tsunami hazard have already been introduced in Class VIII, IX and X levels in the Central Board of Secondary Education (CBSE) schools. Other school boards will develop similar content in their curriculum. State Governments and SDMAs will, in collaboration with their boards of intermediate education, ensure that the subject of disaster safety and disaster preparedness (including tsunami) is introduced at the intermediate education level (Class XI and XII or, their equivalents), as well as at the degree level in the non-technical disciplines. Universities and autonomous institutes will introduce DM (which will include tsunami management) in various educational programmes.

iv. Industrial Training Institutes (ITIs), polytechnics and Universities in the states will develop adequate technical expertise on the various subjects related to DM. State Governments will introduce a five year quality improvement programme for teachers and professionals engaged in teaching the subjects related to tsunami (namely earth science, architecture, ocean engineering and earthquake engineering). The ongoing and recently concluded technical education programmes for college teachers, viz., the Quality Improvement Programme (QIP); the National Programme for Earthquake Engineering Education (NPEEE) supported by the Ministry of Human Resource Development (MHRD), GoI; the National Programme for Capacity Building of Architects in Earthquake Risk Management (NPCBAERM); and the National Programme for Capacity Building of Engineers in Earthquake Risk Management (NPCBEERM) supported by the MHA, GoI, will be further strengthened through the National earthquake Risk Mitigation Project (NERMP) and expanded to address the gap between the requirement and availability of quality teachers conversant with tsunami-safe design and construction. All such training programmes will incorporate testing and certification of trainees.

v. The subject of disaster medicine covers aspects like trauma care, epidemic control, emergency medical care by paramedics and emergency medical technicians, and telemedicine. DM related aspects of medical education will receive detailed treatment at the undergraduate level, so that graduating doctors are able to handle emergencies with a better understanding of the issues involved. MoES will, in consultation with the

Medical Council of India (MCI), University Grants Commission (UGC), and other related agencies, facilitate the introduction of subjects related to DM, in the undergraduate medical curriculum.

vi. The curricula of IITs, NITs, engineering and architecture colleges, ITIs, polytechnics and universities will be suitably modified to incorporate tsunami-safe design and construction techniques. MoES will facilitate this process in collaboration with MHRD, GoI; the All India Council for Technical Education (AICTE); the Council of Architecture (CoA); and the Institution of Engineers (India), to incorporate tsunami-safe design and construction.

vii. All architecture, planning and engineering graduates will be equipped with the requisite knowledge of tsunami-safe planning, design and construction requirements. The focus will be on improving the knowledge and skill set of human resources; reviewing and revising the curricula; strengthening the facilities; and institutionalising appropriate capacity building mechanisms to ensure tsunami safety. The mainstreaming of tsunami management in development planning will be supplemented with the development of the requisite infrastructure in technical and professional institutions, improved laboratories and libraries in knowledge institutions and R&D institutions. These measures will enable them to undertake research, execute pilot projects, and develop resource materials and technical documents for education, sensitisation and training programmes. The DM plans prepared by Central Ministries and Departments and State Governments will address these requirements in detail.

viii. Centres of public interest such as museums and planetariums will be used for the dissemination of information on tsunami risk mitigation to the public and other stakeholders. A few museums of highest standards that are devoted to natural disasters should be set up at various parts of the country as part of efforts on public awareness and education.

(Para 3.12) (Action: MHRD, MoES, NDMA, UGC, AICTE, MCI, ICAR, CBSE, State Governments, UT Administrations, Ministry of Culture)

14. Training and Capacity Building of Professionals

i. In order to increase the thrust towards tsunami education in India, the leading institutes and universities identified by MoES shall create dedicated chaired positions for faculty members working in the area of earthquake and tsunami related education and research. Such institutions will also offer the services of such experienced faculty members to participate in the activities specified in the Guidelines.

ii. In accordance with these Guidelines, the NIDM will evolve an action plan, in collaboration with the ATIs and other technical institutions, to offer a comprehensive curriculum related to tsunami management, in the form of

training modules for the various target groups and initiate the design, development and delivery of the same at the earliest. Training of the Trainers to impart knowledge related to tsunami mitigation measures should be undertaken by the State Governments with the help of IITs, NITs, and other research organisations.

iii. The emergency managers responsible for issuing of tsunami warnings and for responding to tsunami warning require specialised training. Special training programmes incorporating the best global practices will be developed and regular training programmes, including mock exercises and drills, will be imparted for the emergency managers at the national, state and local levels.

iv. Both in-class training and practice based hands-on training will be undertaken for the artisans involved in different trades including masons, bar benders, welders, carpenters, plumbers and electricians. Such training programmes will be offered to large number of diploma or ITI certificate holders who are involved at the civil engineering project sites. The State Governments will also evolve a formal framework for the certification of artisans and adopt a two year certification cycle. One of such formal frameworks could be adding a minimum 40 per cent of total artisans as trained artisans every year since inception of any government construction project by contractors, developers and builders. The contractors, developers and builders, at their own expense, would enrol the artisans in local training institutes run by building centres, NGO and other local organizations to add on minimum requirement of trained masons into their projects. Further, local ITIs and Polytechnics could act as certifying agencies for such trained masons. The respective State Governments/UT administrations should work out such modalities as per their local requirement. Model course modules and training materials in vernacular languages and certification modalities should be made available to training institutes and certifying institutes respectively.

v. The National Institutes of Technical Teachers' Training and Research (NITTTR), state ATIs, National Institute of Construction Management and Research (NICMAR), Construction Federation of India (CFI), Builders Association of India (BAI), and other national bodies will contribute to the national effort to build the requisite number of trained personnel to address tsunami safety in India. They will undertake a campaign of `Training the Trainers' amongst artisans, teachers and practicing professionals in order to meet the gaps in human resource requirement.

vi. MoES shall assign the studies to scientific and technical institutions to carry out the survey and document the effects of tsunamis so as to learn about the nature and impact of the phenomenon and to make recommendations on the need for further research, planning and

preparedness. Such studies shall recommend the modalities to conduct post-tsunami field reconnaissance investigations, and the standards for the observations, measurements, and assessments, so as to properly collect the data in a consistent and timely manner. Studies are needed to be carried out to record the nature and extent of damage and also the possible cause of damage, pressure created by water waves, buoyancy, impact of debris, record the contamination due to hazardous materials, oil spillage, leakage of chemicals etc., distinguish earthquake damage from the tsunami damage and draw post tsunami survey questionnaire, etc.

vii. The capacity building is required at all levels such as Research and Development (R & D) including monitoring and modelling, communication systems, etc. An indicative list of institutions and individual officers to be involved are:

- INCOIS, NIOT, ICMAM and IMD of MoES
- Indian Institutes of Technology (IITs), Chennai, Hyderabad & Kharagpur / University of Madras, Anna University & other coastal universities
- Centre for Earth Science Studies, Thiruvananthapuram
- Bhabha Atomic Research Centre
- State Disaster Management Authorities / CDM Faculty in Institutes
- State Relief Commissioners, Department of Disaster Management, State Government
- Coastal District Collectorates

viii. NIDM will, in consultation with reputed knowledge institutions, develop comprehensive programmes for creating trainers from among trained faculty members of engineering and architecture colleges and professionals. State Governments and SDMAs will identify potential trainers to develop training programmes at basic, intermediate and advanced levels.

(Para 3.13) (Action: Concerned Institutions and Agencies of GoI, State Governments and UT Administrations)

15. Tsunami Preparedness for Far-field and Local Tsunamis

The island states must have their own coping capacities and adequate capabilities to respond to any emergency, without waiting for assistance from the Central Government. They must set up the State Disaster Response Force (SDRF) from their existing police force and train these SDRF personnel with the help of master trainers from NDRF. The medical facilities in the island territories will also be adequately strengthened and the possibilities of deploying medical ships or medical boats to remote islands will be explored by the health administration. The availability of floating jetties and strengthening of refuelling capabilities in various air strips in Andaman and Nicobar islands will be explored. Wherever necessary, the existing resources of the Coast Guards, Indian Navy,

Pawan Hans helicopters and Indian Air Force will also be utilised by the administration of the island territories to meet emergency requirements with the approval of the Central Government.

(Para 3.14) (Action: State Governments, UT Administrations and MoD)

16. Medical Preparedness

i. NDMA has already released the National Disaster Management Guidelines on Medical Preparedness and Mass Casualty Management. As envisaged in these Guidelines, the DM plans prepared at the state and district levels will have sections incorporating all-hazards medical management to improve emergency medical preparedness and emergency medical response. Medical preparedness from tsunami risk will focus on likely injuries, outbreak of diseases and other post tsunami public health problems including psycho-social trauma. Tsunami specific modules will earmark the healthcare facilities, roles of local medical professionals, mechanism for prevention of post-tsunami epidemics of zootomic and water-borne diseases in the area, community professionals trained in psychosocial care and medical support linkages with other districts away from the coastline. It will also address the need for surveillance and for planning and rehearsing tsunami preparedness through mock exercises.

ii. The Medical Management Plan will address the need to create greater awareness in all medical teams and the medical community at large with regard to frequent type of injuries, illness and other health problems caused by tsunamis. Trained Medical First Responders (MFRs) for administering first-aid and resuscitation measures, at the incident site and during transportation of casualties. In addition to MFRs of the National Disaster Response Force (NDRF), DM plans at all levels will identify medical and paramedical staff to supplement manpower resources at district and state levels. All members of the medical and paramedical teams will carry out regular exercises based on the Standard Operating Procedures (SOPs) laid down by the respective DMAs as part of their DM plan.

iii. A uniform casualty profile of tsunami injuries will be created and a system of triage to classify casualties will be institutionalised so that the treatment can effectively be facilitated by the medical authorities concerned. This plan will include inventory hospitals and their telephone numbers, availability of ambulances, doctors, anaesthetists, specialists, paramedical staff, sources of public and private sector medical resources, and commonly needed medical supplies and medical stores, blood banks, heli-ambulances and floating hospitals, etc., for easy accessibility. SOPs for medical evacuation, transport of victims and treatment of the injured will also be included.

iv. All public health facilities will develop their own DM plans, with the scope

for enhancing their surge capacity in the event of disaster. Training exercises and mock exercises and drills will be carried out regularly by doctors as well as paramedical staff. The medical preparedness plans will also include the identification of trained trauma and psycho-social care teams including nursing and paramedical staff. In the coastal areas vulnerable to tsunami, mobile hospitals and Quick Reaction Medical Teams (QRMTs) will be developed as a part of the health-care delivery system of the states to manage patients with minor injuries at the incident site. The Accident Relief Medical Vans (ARMVs) of the Railways will also be deployed to provide immediate emergency medical services in the event of a tsunami disaster.

(Para 3.15) (Action: State Governments, UT Administrations)

Chapter 4: Structural Mitigation Measures

17. Mainstreaming DM in Developmental Planning

The Ministry or Department of the GoI or the State Government which submits the proposal for plan schemes have to ensure that the physical and regulatory measures that must necessarily be taken based on design and engineering or technology to prevent or mitigate the effect of such disasters have been incorporated within the proposed financial allocation being sought. The appropriate engineering and non-engineering options for risk treatments to the multi-hazard context will have to be incorporated in the proposal for mainstreaming DM concerns in developmental planning at the National, State and District levels.

(Para 4.1.2) (Action: All line Ministries and Departments, State Governments, UT Administrations)

18. Need for New Standards for Protection of Structures Against Tsunami

BIS will ensure that the Draft Standards entitled "Criteria for Tsunami-Resistant Design of Structures" are finalised on priority and disseminated widely. BIS will also develop other necessary standards for the safety of natural habitats against tsunami and storm surge. BIS will also periodically review the standards and codes prepared by them and wherever necessary, ensure that these standards and codes are revised and updated regularly and placed in the public domain.

(Para 4.2.2) (Action: BIS)

19. Shelters for Storm Surges and Tsunamis

Cyclone-cum-tsunami shelters should be designed in such a way that they address multi-purpose uses. Such multi-purpose uses will ensure that such structures do not fall into disuse when there is no threat of cyclones or tsunamis. This would ensure their proper maintenance by the community itself. Cyclone-cum-tsunami shelters should be so designed so as to take care of the livestock of the communities, wherever possible, while protecting the local people.

(Para 4.3.2) (Action: State Governments, UT Administrations)

20. Institutionalisation of Design and Construction for Tsunami Safety

In the design of public infrastructure like roads, schools, hospitals, multi-purpose shelters etc., prevailing risk and vulnerability has to be kept in mind. In tsunami-prone areas, the DDMAs will ensure that a bank of designs of temporary shelters, intermediate shelters and disaster-resilient houses shall be prepared, with the flexibility to use traditional and local knowledge, coping capacities and locally available shelter materials.

(Para 4.4.1) (Action: State Governments, UT Administrations, SDMAs and DDMAs)

21. Tsunami Mitigation Measures

i. Coastal villages can be safeguarded from the impact of tsunami by adopting soft solutions and by educating the villagers to follow simple precautionary measures as illustrated at para 4.5.1 of these Guidelines.

(Para 4.5.1) (Action: State Governments, PRIs, UT Administrations, SDMAs and DDMAs)

ii. During the Indian Ocean Tsunami of December 2004, the damage to port and harbour structures was observed to be much severe than that in the other structures away from the coast. These structures were subjected to ground shaking due to earthquake and wave action due to tsunami. These structures are founded generally on soft ground with more than one type of foundation system in a structure. Ground subsidence and liquefaction has been commonly observed and was one of the major reasons of common damage. Favourable conditions for corrosion exist near the sea and damage has been observed to be more at corroded locations. The earthquake also exposes the deficiencies caused by faulty design and construction. The recommended design solutions and specifications against various observed tsunami effects, as given in the tables under para 4.5.2 and 4.6 should be taken into consideration in new design and construction of structures.

(Para 4.5.2 and 4.6) (Action: State Governments, PRIs, UT Administrations, SDMAs, DDMAs, Builders and Individual developers)

22. Protecting Seafronts and Lifeline Structures

i. While these Guidelines indicate an illustrative list of critical lifeline buildings and structures at table 4.7, the State Governments/SDMAs will, in consultation with knowledge institutions such as IITs and NITs and Hazard Safety Cells (HSCs), review their existing built environment, and prepare such lists.

(Para 4.7.3) (Action: State Governments, UT Administrations)

ii. Some lifeline structures such as primary schools, primary health centres, panchayat offices, post offices and Block Development Offices may be selected in potential tsunami run-up areas to study their ability to withstand tsunami forces. Where feasible, select priority lifeline structures will be strengthened. The

strengthening will provide valuable demonstration of their efficacy. The State Governments/SDMAs will take up selected critical lifeline structures in some of these high-risk areas as pilot projects in a phased manner. Other critical lifeline structures should be considered for relocation away from the vulnerable areas.

(Para 4.7.4) (Action: State Governments, UT Administrations)

iii. DDMAs will explore the inclusion of coastal protection measures to be eligible for schemes like National Rural Employment Guarantee Scheme, as they will meet the employment generation objective and provide the much needed protection to the fragile coastal areas.

(Para 4.7.7) (Action: State Governments, UT Administrations, SDMAs and DDMAs)

23. Prioritization of Structures

i. All Central Ministries and Departments and State Governments will draw up phased programmes for strengthening and/or possible relocation of selected existing structures duly prioritised and implement them through ULBs and PRIs. Like all new construction, any structural modification of existing buildings will also require compliance with safety regulations against tsunami.

ii. The necessary capacity for carrying out similar structural safety audit and strengthening for private buildings will also be developed through suitable capacity development efforts among the professionals in the private sector. The nodal agencies will make available the details of technical guidance for carrying out structural safety audit of lifeline structures and their strengthening in public domain for the use of the general public and professionals in the private sector. The seafront shall be prioritised for strengthening on the basis of the vulnerability of the natural resources, lifeline structures and the local community. The necessary capacity for carrying out vulnerability assessment shall be developed through suitable capacity development efforts among the various government agencies.

(Para 4.8) (Action: State Governments, UT Administrations)

24. Structural Safety Audit of Seafront, Coastal Natural Resources and Critical Lifeline Structures

i. Organisations like IITs, National Building Construction Corporation Ltd. (NBCC), Building Material Technology Promotion Council (BMTPC), Central Building Research Institute (CBRI), Structural Engineering Research Centre, Chennai (SERC), the Institution of Engineers (India) (IE[I]), Construction Industry Development Council (CIDC), Construction Federation of India (CFI), and the National Academy of Construction (NAC), will be associated to develop road maps for creating the required manpower, tools and construction management system to implement the structural strengthening challenge in

India. In consultation with these agencies, a standardised procedure for vulnerability assessment will be prepared at the national level to clarify the process and issues involved in the strengthening of each type of structure as per national standards.

ii. The vulnerability assessment of the seafront and coastal natural resources can be carried out only on the basis of reliable large-scale maps. Assessment techniques may be used to determine the vulnerability of structures of seafront in the order of priority decided by the State Governments/SDMAs, in consultation with their SEMCs and HSCs. Multi-level vulnerability assessment can be carried out for these structures. The quick and approximate assessment of tsunami amplification can be carried out by using available terrain and bathymetry data. In densely populated regions or in other areas, as required by the State Governments/SDMAs, more detailed assessment can be carried out later using large-scale maps.

(Para 4.9) (Action: State Governments, UTs)

25. Protecting and Strengthening

i. The Government shall launch targeted programs similar to GoI-UNDP supported UEVRP for tsunami safety. Under this program, protecting and strengthening of some fragile seafront, coastal natural resources and lifeline structures will be undertaken through pilot projects in a phased manner. The prioritisation of the cities will be based on the degree of tsunami hazard, population size, level of vulnerability of the building/structure, importance of the lifeline structure and coastal natural resources, and the speed with which the states can undertake these initiatives. The cities are to be identified based on these criteria for strengthening of selected lifeline structures. In the first priority, metropolitan cities and major townships in high tsunami run-up regions may be taken up.

ii. Insurance companies will be encouraged to introduce innovative insurance schemes in moderate and high tsunami-risk coastal zones in consultation with the ULBs and respective Disaster Management Authorities (DMAs).

iii. State Governments/SDMAs will initiate efforts to compile GIS databases and develop a GIS data bank consisting of GIS maps for all urban areas, indicating vulnerable seafront and natural resources, all critical structures and infrastructures.

iv. State Governments/SDMAs will develop appropriate mechanisms, in consultation with their SEMCs and HSCs, to review and ensure structural safety of existing public buildings in accordance with the latest norms during any significant alterations or additions to them. Similar process should also be carried out in respect of defence works/structures in high tsunami-risk areas.

v. The Government of India will utilize the national rural employment guarantee scheme and other similar schemes for using local manpower for constructing and strengthening of protective seafront structures. The local community will be given the responsibility of maintenance and upkeep of these structures to ensure community participation in disaster management efforts.

vi. The GoI can generate new incentives to promote through policy decisions and to allow tax-holidays, to private/ Corporate sector for their contributions to build and operate priority structures such as Tsunami-towers/platforms/shelters, as part of their CSR (corporate social responsibilities) activities.

vii. As far as possible, local authorities will discourage the construction of structures in areas vulnerable to high tsunami risk. In case of construction of structures in areas prone to sea erosion and high risk of tsunami, the professionals involved in the design and construction of such structures will be made aware of the tsunami risk and vulnerability in such areas.

viii. MoES, in co-operation with other concerned Ministries and Departments of GoI and State Governments and other specialised agencies, will initiate the efforts for developing a Data Base of Tsunami Risk and Vulnerability in the coastal areas of the country, with information on trends of storm surge, high tides, local bathymetry, etc. for providing value-added information to the general public for protecting the investments proposed to be undertaken through construction of structures on the sea front. Once the Data Base is developed, MoES will make it available in the public domain, wherever possible, or accessible to the professionals who are involved in the construction of such structures after confirming the authenticity of such requests.

(Para 4.10) (Action: Govt. of India, MoES, State Governments, UT Administrations, SDMAs, DDMAs, ULBs, HSCs)

Chapter 5: Regulation and Enforcement of Techno-Legal Regime

26. Land Use

Effective implementation of building bye-laws is to be ensured by the State Governments and ULBs in construction of buildings and local infrastructure should be strengthened to make them resistant from tsunami and cyclonic sea surge.

(Para 5.1.2) (Action: State Governments, UT Administrations)

27. Options for Efficient Land Use Practices

(i) Based on information received from the states, groups of experts from Ministry of Environment & Forest, Botanical Survey of India, Zoological Survey of India, State Governments

and some 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.

(Para 5.3.1) (Action: State Governments, UT Administrations, State Remote Sensing Application Centres)

(ii) To bring mangrove regeneration under suitable and secured land use zoning, following actions will be initiated:

a) Set up a Task Force in consultation with states to identify new mangrove areas on priority to enhance the spread of the mangrove areas in various states within 6 months.

b) Launch the dual mode mangrove plantation programme.

c) Direct planting of seeds or propagules in the muddy areas (plenty)

d) 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.

e) Species selection is to be made based on the availability and maturity of planting materials from the locality.

f) Zonation pattern is to be considered primarily in restoration work.

g) State governments should make aggressive and sustained efforts to conserve the existing mangroves.

h) Initiate intensive mangrove plantation programmes at identified potential sites so as to develop bio-shields.

i) Mangroves should be officially classified as forests and mangroves found anywhere should be placed under the control of the state forest departments. The important mangrove areas need to be declared as protected areas if they are not so covered already.

j) A concerted effort needs to be made 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.

(Para 5.3.1) (Action: State Governments, UT Administrations)

(iii) Following actions will be initiated for effective shelter belt plantation at coast lines.

i. Raising of coastal shelterbelts will be made a mandatory component of the National Afforestation Programme (NAP) plans by MoEF.

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 the coastal bio-shields for facilitating the implementation.

(Para 5.3.2) (Action: MoEF, State Governments, UT Administrations)

28. Selection of Species and efforts for community involvement

The shelterbelt plantation programme has to be taken up on a regular basis and specifically after the passage of each cyclone and tusnami. Tidal amplitude is an important factor to be considered for species selection and is easily measured by calculating distance between the highest high-tide to 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 main and support zones up to 5000m from the coastline are to be implemented truthfully through Joint Forest Management (JFM) concept and the afforestation through Vana Samrakshana Samitis (VSS) along with accrued monitory benefits. Community involvement and beneficiary oriented nursery programmes are crucial for the regeneration of forest cover and coastal shelterbelt consolidation. This should be encouraged.

(Para 5.4) (Action: MoEF, State Governments, UT Administrations)

29. Monitoring Shelterbelt Plantations and Mangrove Regeneration Zones

Following are the desired action points for mangrove regeneration and shelter belt plantation with effective zoning regulation:

i. MoEF jointly with state government departments should take leadership and commission a state-wise survey of conserved areas which would be appropriately designated as community reserves, and have them notified by the respective State Governments for preparation of management plans

ii. Local communities living in and around forest areas are to 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 5000m of coastline by utilizing high resolution remote sensing satellite images from CARTOSAT type satellites may be established to monitor coastal shelterbelt plantations

iv. Establishment of a dedicated IFS sub-cadre for conservation and a training centre for coastal and marine biodiversity conservation and management are necessary

vi. An Institutional mechanism to empower Coast Guards to enforce the Wild Life (Protection) Act, 1972, up to 500m of coastal stretches must be considered

(Para 5.5.2) (Action: MoEF, State Governments, UT Administrations, NRSC, Indian Coast Guard)

30. Funding Support for the spread of Mangroves and Shelterbelts

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. The National Afforestation Programme (NAP) was started as a 100% Central Sector Scheme during the X five year plan. NAP is implemented by involving two tier setup namely Forest Development Agency at Forest Division level and Joint Forest Management (JFM) Committee at Village level. On an average, about Rs 250 crores are allocated for NAP during the Plan period covering all states of the country but without any special emphasis on restoration of coastal bio-shields. DDMAs will make special efforts to ensure that employment generation schemes like NREGA will be specially made applicable in tsunami-prone areas for establishing shelter belt plantations and mangrove plantations.

(Para 5.6) (Action: MoEF, State Governments, UT Administrations, SDMAs, DDMAs)

31. Techno-Legal Regime for Coastal Zones

i. The BIS has recently proposed a draft standard entitled Criteria for Tsunami-Resistant Design of Structures. The BIS will complete the review process and issue this code at the earliest. The BIS shall also develop other necessary standards such as those for the safety of natural habitats against tsunami. Considering the overriding interest of public safety, the BIS will place all Indian standards related to tsunami safety in the public domain including the internet for free download as and when they are issued.

ii. State Governments/SDMAs will, in consultation with their SEMCs and HSCs, establish the necessary techno-legal and techno-financial mechanisms. This is to ensure that all stakeholders like planners, builders, architects, engineers and government departments, responsible for regulation and enforcement adopt tsunami-safe zoning, planning and construction practices and provide for safety in all design and construction activities in such a way that acceptable safety benchmarks against tsunami are satisfied.

iii. The model techno-legal framework prepared by the expert group of Ministry of Home Affairs shall incorporate relevant zoning for tsunami safety, planning, design and construction practices. The modifications to incorporate these provisions will be carried out at the earliest.

iv. All State Governments/SDMAs in tsunami-risk regions will adopt the model techno-legal framework for ensuring compliance of tsunami-safe zoning, planning, design and construction practices in all new

constructions. State Governments will update the urban regulations by amending them to incorporate multi-hazard safety requirements. State Governments will review, revise and update the town and country planning Acts, land use and zoning regulations, building bye-laws and DCRs, and this process will be repeated at least once every five years.

v. The designs of some structures in tsunami-prone regions, randomly selected by the ULBs, will be subjected to detailed technical audit for reviewing the entire design process and detailed design calculations. A procedure will be developed by each State Government/SDMA for undertaking this third party audit or external compliance review by accredited agencies for ensuring the review of a structural safety audit. In particular, the external compliance review of seafront structures, lifeline buildings and infrastructure in tsunami-prone areas will be undertaken as per the recommendations of the expert group set up by the MHA, GoI.

vi. Specific illustrative guidelines will be issued by State Governments for each non-engineered construction type in tsunami-prone areas and demonstrated through the construction of new public buildings in villages. For instance, the buildings of panchayat offices, post offices, primary schools and primary health centres in rural and semi-urban areas will be used as demonstration buildings.

vii. State Governments will develop suitable bye-laws for rural areas where most buildings are non-engineered, keeping in mind the local conditions, and extend them to the rural areas, especially on priority in high-risk areas. State Governments/SDMAs, in consultation with SEMCs, HSCs and Panchayat Raj Institutions will regulate all future constructions at coast lines to provide safety against tsunami.

(Para 5.7) (Action: State Governments, UT Administrations)

32. Techno-Financial Regime

i. In most countries, risk transfer through insurance has been adopted as a step towards providing adequate compensation for the loss of property caused by disasters. Such a mechanism reduces the financial burden of the government. Risk transfer mechanisms have been found to be fairly successful and hence, the insurance sector will be encouraged to promote such mechanisms in the future. The risk transfer mechanism shall cover not only the privately owned structures, but also government-owned structures and coastal natural habitats.

ii. The Ministry of Finance will develop a national strategy of risk sharing through micro-finance and self-help groups reaching to the most vulnerable communities. The MoF will facilitate the development and design of appropriate mechanisms to ensure the viability and long-term subsistence

of these micro-level risk transfer mechanisms.

iii. Financial institutions will consider the compliance of safety against tsunami before offering housing loans including those for construction of industrial, commercial and multi-storied complexes. The construction programmes supported by the GoI and State Governments (like Indira Awas Yojana), and all large-scale housing schemes will be made to comply with design and construction practices for safety against tsunami.

iv. In tsunami-prone coastal areas, the approval and disbursement of funds from banks and other financial institutions to industrial units will also be linked to the compliance with tsunami safety norms by these units. The MoES will coordinate with the relevant bodies for development of suitable techno-financial measures to improve the tsunami safety of the industrial units' corporate groups, Special Economic Zones (SEZs), techno parks etc. located in tsunami-prone regions.

v. National Disaster Management Guidelines on Techno financial Issues like Risk Sharing, Risk Transfer, Insurance issues needs to be prepared which will deal with techno-financial strategies for addressing various disaster risks.

(Para 5.8) (Action: State Governments, UTs)

Chapter 6: Emergency Tsunami Response

33. Tsunami Response Requirement

As soon as the warning is issued, the Tsunami Response Plan will be activated in the concerned areas. Response to early warning would involve safe evacuation of community population with minimal loss to property (living and non-living assets). Depending on the scale of Tsunami, the run-up height and level of storm surge, the scale of response will be mobilised at community, district, state and national level. Systems will be institutionalised by the DMA's, at various levels for coordination between various agencies like Central Government Ministries, Departments, State Governments, district authorities, ULB's, PRI's and other stakeholders for effective tsunami response.

(Para 6.1) (Action: State Governments, UT Administrations, SDMAs,DDMAs)

34. Emergency Search and Rescue

Community-level teams will be developed in the coastal districts with basic training in search & rescue. Training modules will be developed for trainers of community level search & rescue teams by NDRF training institutes. On ground, the NDRF Battalions will assist the State Government/district authorities in training communities. They will be further assisted by Civil Defence, Home Guards, Fire Services and NGOs. State Governments will develop procedures for formally recognising and certifying such trained search & rescue team members. State Governments will provide suitable indemnity to the community level team members for their actions in the course of

emergency response following an tsunami. Youth organisations such as National Cadet Corps (NCC) and National Service Scheme (NSS) and Nehru Yuva Kendra Sangathan (NYKS) will provide support services to the response teams at the local level under the overall guidance and supervision of the local administration.

(Para 6.2) (Action: NDRF, State Governments, UT Administrations, NYKS, NCC, Civil Defence)

35. Emergency Relief

The concerned Indian Navy and Coast Guard forces will extend close cooperation by supporting boats, latest equipments, skilled/ trained man power and other possible assistance to local administration for carrying out rescue and relief activities in the tsunami affected areas.

(Para 6.3.2) (Action: Indian Navy, Coast Guards)

36. Incident Response System

NDMA has prepared the Guidelines on Incident Response System (IRS) in collaboration with all concerned stakeholder groups for streamlining the coordination of response in the event of a sudden occurrence of any disaster. This will be operationalised through Incident Response Teams (IRTs) at appropriate levels for effective coordination of response. All response activities will be undertaken at the local level through a suitably devised IRS, coordinated by the local administration through well-equipped Emergency Operations Centres (EOCs) with appropriate computer hardware, software packages and data bases. State Governments will commission and maintain EOCs at appropriate levels for coordination of human resources, relief supplies and equipment. SOPs for the EOCs will be developed by State Governments and integrated within the framework of the IRS, which will take advantage of modern technologies and tools, such as GIS maps, scenarios and simulation models for effectively responding to disasters. GIS maps available from other sources such as the city planning departments, state space application centres and other such sources, will be compiled considering their potential application after a disaster. State Governments/SDMAs will undertake training of personnel involved in IRS.

(Para 6.4) (Action: State Governments, UT Administrations, SDMAs)

37. Community-Based Disaster Response

i. A number of organisations, like NGOs, Self Help groups, Community Based Organisations, youth organizations, women's groups, volunteer agencies, civil defence, home guards, etc. normally volunteer their services in the aftermath of any disaster. State Government/SDMAs and DDMAs will coordinate the allocation of these human resources for performing various response activities. State Governments will work with these agencies to understand and plan their roles in the command chain of the IRS, and incorporate them in the DM Plans.

ii. Large-scale disasters draw overwhelming humanitarian support from different stakeholders. The relief and response activities carried out by such stakeholders will comply with the norms prescribed by the appropriate authorities.

iii. After a Tsunami, accurate information will be provided on the extent of the damage and the details of the response activities through electronic and print media. State Governments will utilise different types of media, especially print, radio, television and internet, to disseminate timely and accurate information.

iv. Special efforts will be made by the DDMAs to enlist the support of NGOs and humanitarian agencies to ensure that in the event of a sudden occurrence of a tsunami, adequate emphasis will be placed on restoration of livelihoods of the tsunami affected people disrupted by the tsunami. The needs of psycho-social support and trauma care of the tsunami affected people will also be met through special efforts by trained social workers and clinical psychologists.

(Para 6.5) (Action: State Governments, UT Administrations, SDMAs, DDMAs)

38. Involvement of Corporate Sector

State Governments will facilitate the involvement of the corporate sector in making available their services and resources to the Government during the immediate aftermath of Tsunami. The Corporate sector, as a part of the Corporate Social Responsibility, can initiate appropriate projects in partnership with Government agencies through Public Private Partnership (PPP). Such PPP projects may provide inter alia the services of hospitals, power and telecommunication, relief supplies, search & rescue equipment, transport and logistics for movement of relief supplies to the extent possible and technical services for restoration and reconstruction of damaged infrastructures.

(Para 6.6) (Action: State Governments, UT Administrations)

39. Specialised Response Teams

i. All 144 teams of NDRF will be especially equipped and trained in search & rescue operations during a tsunami event. The NDRF battalions will also be provided with communication equipment for establishing last mile connectivity.

ii. The Home Guards, the auxiliary arm of the Police force, shall support the district administration in various disaster response tasks.

iii. Parliament has passed the legislation for amendment of clause (a) of Section 2 of the Civil Defence Act, 1968 relating to definition of "civil defence" so as to bring within its scope the "Disaster" and "Disaster Management" as defined in clauses (d) and (e) of section 2 of the Disaster Management Act, 2005. Further, country's Civil Defence set up is being reoriented to assist in handling Disaster Management. Members of these organisations will be trained in tasks like search & rescue and evacuation, protection of assets in evacuated areas, and management of relief camps and aid distribution centres, etc.

(Para 6.7) (Action: NDRF, Civil Defence, Home Guards)

40. Improving Tsunami Response

i. To augment the capacities of the states, all State Governments will

raise, from within their armed police force, adequate strength of personnel for raising of State Disaster Response Force (SDRF) with appropriate disaster response capabilities.

(Para 6.8) (Action: State Governments)

41. Evacuation plans and Shelters

i. Inflatable motorised boats, helicopters and search & rescue equipments are required immediately after a tsunami to carry out search and rescue of people trapped in inundated areas, on tree tops and hanging on to structures. State Governments will compile a list of such equipment and identify suppliers of such specialised equipments and enter into Long Term Agreements for their mobilisation and deployment in the event of tsunami. India Disaster Resource Network (IDRN), which is a web-based resource inventory of information on emergency equipment and response personnel available at every district, will be revised and updated frequently. The IRS will also provide a web-based system for monitoring the emergency logistics requirements of disaster-affected villages as well as the flow of emergency relief supplies to the affected villages.

ii. The setting up of relief camps for the people whose houses have been damaged by tsunami or flooded by the storm surge and the provision of basic amenities in such camps involves complex logistics of mobilising relief supplies, tents, water supply and sanitation systems, transport and communication systems, and medical supplies. Immediate restoration of power supply would be essential to carry out relief operations. The DM Plans at the State and District levels will address this issue in detail. An information booth for victims would be established by the district authorities.

iii. In the event of mass casualties, States/UTs will develop systems for proper identification of dead bodies, recording the details of victims, and their DNA fingerprinting.

(Para 6.9) (Action: State Governments, UT Administrations, SDMAs, DDMAs)

42. Emergency Medical Response

i. Prompt and efficient emergency medical response will be provided by Quick Reaction Medical Teams (QRMTs), Mobile Field Hospitals, Accident Relief Medical Vans (ARMVs) and Heli-ambulances. They will be activated to reach the tsunami-affected areas immediately, along with dressing material, splints, portable X-ray machines, mobile operation theatres, pulse oximeters, resuscitation equipment and life-saving drugs, etc. Resuscitation, triage and medical evacuation of victims who require hospitalisation will be done in accordance with SOPs. A large number of victims may suffer from psycho-social trauma, for which appropriate counselling will be provided.

ii. The medical response plan will integrate all aspects of emergency medical management at the incident site, medical care facilities during

transportation and evacuation, adequate ambulance services with defined evacuation routes and other communication linkages and coordination with other identified agencies.

iii. The emergency medical plan will be operationalised immediately on receiving information from the tsunami-affected areas. Hospitals in the affected areas will create a surge capacity for the required number of beds by discharging non-critical patients and mobilise doctors and support staff, additional orthopaedic equipment and supplies at short notice from non-coastal areas. The emergency medical plan will identify the requirement of enhanced manpower, medical stores and the requirement of blood and its components. After a tsunami, information centres will be set up to provide medical response information to the public, relatives of victims and media. The designated hospitals will also identify the surgical teams that can be deployed in the field at short notice and arrange for their transport, medical equipment and supplies. State Governments will coordinate with both government and private hospitals in order to facilitate effective and adequate hospital response after tsunami.

iv. Documentation of medical response provided after a tsunami will be done by a medical administrator. This documentation will be used as feedback for future improvement of the response strategies.

(Para 6.10) (Action: State Governments, UT Administrations)

43. Role of the Indian Naval Hydrographic Department (INHD) in Response

INHD plays a very significant role, especially during natural disasters that affect the coastal areas. INHD also be pressed into action during any future tsunami emergency.

(Para 6.11) (Action: INHD)

Chapter 7: Preparation of National Disaster Management Plans

44. Preparation of National Disaster Management Plans

In accordance with the various disaster-specific Guidelines laid down by the NDMA, the NEC will prepare the National Disaster Management Plan, incorporating the DM plans prepared by the Central Ministries/Departments and State Governments. This Plan, inter alia, will include various aspects of tsunami management as laid out at Section 7.1.2 of these Guidelines and be approved by the NDMA.

(Para 7.1) (Action: NEC, NDMA)

45. DM Plans of Central Ministries and Departments

Each Central Ministry/Department will prepare its DM plan which will cover all aspects of the disaster cycle for every disaster, including tsunamis as defined at Section 7.2 of these Guidelines.

(Para 7.2) (Action: Concerned Ministries/ Departments of GoI)

46. DM Plans of State Governments

i. In accordance with Section 7.3.1 of these Guidelines, all the Coastal States and UTs, while preparing State DM Plan, shall include the vulnerability of different parts of their states/UTs to tsunami and measures to be adopted for prevention, mitigation, capacity building and preparedness to tsunami disaster.

ii. Authorities in charge of education institutions falling in tsunami risk zones will prepare tsunami preparedness plans and conduct mock exercises and drills. Using school buildings as temporary relief camps during disasters disrupts the education of children for long periods. Alternative arrangements for accommodating relief camps will be put in place through various mitigation projects to gradually reduce the dependence on the buildings of educational institutions.

iii. All hospitals of coastal areas will develop their emergency plans, conduct mock exercises and drills and update themselves from time to time with relevant information on tsunami disaster management and preparedness. State Governments/ SDMAs will monitor the preparation and testing of these plans. State Governments will ensure that all government offices are able to withstand tsunami, and are fully prepared with DM plans.

iv. The DM plans will incorporate all the features of the EOCs including their establishment and operations.

(Para 7.3) (Action: State Governments, UT Administrations)

47. DM Plans of Departments of State Governments and UT Administrations

As defined at Section 7.4 of these Guidelines, all the Departments of Coastal State Governments and UT Administrations, concerned to tsunami in any way, will identify the measures for prevention and mitigation of tsunami in their DM Plans in accordance with the National and State DM Plans and national and state level DM Guidelines.

(Para 7.4) (Action: State Governments, UT Administrations, SDMAs)

48. DM Plans of Nodal Agencies

i. The Indian National Centre for Ocean Information Services (INCOIS) is the national tsunami warning centre and is the nodal agency for monitoring of tsunami in India and provides information based on predictive models through their network of observatories. It will record the occurrence of any tsunami impending to any part of Indian coasts and report the same to various designated functionaries in the GoI and the State Governments.

(Para 7.5.1) (Action: INCOIS)

ii. The BIS is the nodal agency for preparing earthquake- and tsunami-

safe building codes and other safety related codes. For structures like dams, the responsibility lies with the Central Water Commission (CWC), while for the bridges, it lies with the Indian Roads Congress (IRC). The Indian Standards Committees set up by the BIS have been working on the revision and finalisation of tsunami safe codes. The BIS will ensure finalisation of all pending revisions within the next two years.

(Para 7.5.3) (Action: BIS)

iii. The MoES has been set up by the Government of India to bring together the Earth Commission, the IMD, and other key institutions to facilitate effective coordination of the various aspects related to the ocean, meteorology, seismology, marine environment, atmosphere and earth sciences, not specifically allotted to any other Department or Ministry. As the nodal agency for tsunami management, the MoES will prepare their DM plan based on the Guidelines laid down by the NDMA. The various aspects of the DM plans prepared by the other Central Ministries/ Departments and State Governments and other stakeholder groups will be included in the DM plan prepared by the MoES, GoI. The MoES will also prepare a comprehensive plan for the upgradation of the capabilities of the IMD with clear roadmap and milestones.

(Para 7.5.4) (Action: MoES)

49. Implementation of the Tsunami Management Plan

Planning, executing, monitoring and evaluating are four facets of the comprehensive implementation of the Guidelines. If desired, MoES can co-opt a Specialist nominated by NDMA to assist them in the preparation of the Plan. The Tsunami Management Plan prepared by MoES in consultation with coastal states and concerned nodal agencies will be implemented with the support of SDMAs, DDMAs and nodal agencies.

(Para 7.6) (Action: MoES, SDMAs and DDMAs)

50. Financial Resources for Implementation

i. The sources of funding for all Tsunami Management Plan related activities will be as follows:

a) Annual Plan/Budget: for mainstreaming Tsunami Management Plans into developmental plans of respective ministries/ departments at the centre and state governments/UTs.

b) Centrally Sponsored/Central Sector Schemes.

c) National Mitigation Projects by NDMA and other specific projects either by the central government or state governments; funded internally/ externally.

d) Public-Private Partnership.

(Para 7.7.3) (Action: GoI, NDMA)

ii. 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 tsunami resistant design and construction practices.

(Para 7.7.4) (Action: MoCI)

iii. 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 Guidelines 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.

(Para 7.7.5) (Action: MoF)

Annexures

Annexure I
Toolkit for Tsunami Risk Management

Spatial Database

It has been observed that several institutions have produced databases at different scales and based on different technologies, which can possibly be used for Disaster Management (DM) activities. Further, some central administrative departments like Department of Science and Technology (DST), MoEF etc have sponsored Mapping and Spatial data Projects to various research institutes in the country. Hence, databases may be available in a sporadic fashion. Some of the databases may cover the DM priority areas.

The available and proposed databases have to be assessed for the DM purposes. NDMA should approach these institutions (including Industries) to get the data.

Databases are related to different scales of maps generally available in the country. They are as follows:

a. 1:250,000 scale: Approximately 400 sheets, covering the whole country and digital database is now available with Survey of India (SOI).

b. 1:50,000 scale: Approximately 5000 sheets, covering the whole country and the digital database is almost ready with SOI. Digital data bases on coastal land use, wetlands, coral reefs, shoreline, High Tide Line (HTL) & Low Tide Line (LTL) for entire Indian coast are available with other national organisations such as Space Applications Centre (SAC).

c. 1:25,000 scale: Approximately 20,000 sheets, covering the whole country and about 60% of the hard copy data is available with SOI. Digital data on coastal landuse, HTL & LTL for entire Indian coast are available with SAC.

d. 1:10,000 scale: There are several institutions interested in the scale but no major initiatives have been taken so far for preparation of maps at this scale. The Planning Committee of Natural Resource Management System (PC-NNRMS) has also proposed to prepare maps for the entire country at this scale. Approximately, 1,200,000 sheets will cover the whole country. The 1-meter contour interval at this scale would be extremely useful for DM activities. Various NDMA committees have also recommended mapping at this scale.

e. 1:5,000/1:2,000 scale: Various Core Groups and committees set up by NDMA have expressed the need to have maps on 1:2,000 or 1:5,000 scale for selected areas with a contour interval of 0.5 meter. Mapping of a few cities have been undertaken by different agencies including SOI at this scale. The high risk areas can be identified on priority for taking up the preparation of maps at this scale.

Bathymetry/Topography

Unlike wind waves, tsunami are long period waves, due to which the focussing/ defocusing of tsunami in coastal areas are decided by the bathymetric features of the shelf and beyond. Thus there is need for detailed bathymetry of the seas surrounding the country, particularly the shelf region, to facilitate tsunami inundation modelling and mitigation activities. Considering the exorbitant cost involved in acquiring the data, a staggered grid size for bathymetric data as below is proposed, judiciously balancing the cost and data resolution requirements:

Depth zone	Grid Size
Shoreline to 20m	100m
20-50m	500m
50-200m	1000m

The grid sizes in the present naval hydrographic charts are far below the requirement. Hence concerted action is required to acquire high resolution bathymetric data for the Indian coasts. It is understood that the Ministry of Earth Sciences has taken up this task already.

Some projects have been approved by different Ministries for topographic survey of coastal areas using Airborne Laser Terrain Mapping (ALTM)/ Aerial Photography. These projects are awaiting clearances from MOD and shall be completed with highest priority in the regions with high tsunami risk.

Remote Sensing Data

India has well developed Satellite and Remote Sensing technology. DM activities must explore the benefits of these initiatives. There are remote sensing data from IRS series as well as OCM and CARTOSAT data. These datasets would definitely help in updating landcover and infrastructure of the priority area.

The remote sensing data should also be used for DEM (Digital Elevation Model) as well as updation at regular intervals, at least once in 5 years.

GIS Database

There are several agencies and institutions at national and state levels, apart from Universities and research institutions, which have generated huge GIS databases. These digital assets have to be explored for possible use for DM purposes. A few of such institutions are :

- State Geospatial Data Centre (GDCs) of Survey of India
- State Remote Sensing Application Centres
- Institutes of Remote Sensing (National / State)
- National Remote Sensing Centre (NRSC)

- Survey of India (SOI)
- National Atlas and Thematic Organization (NATMO)
- Space Applications Centre (SAC)
- Various IITs

These institutes should be encouraged to provide data to the NSDI. Their data model contents and codifications have to be made homogeneous. For this matter, the NSDI/ NNRMS standards may be considered. In addition, the Tsunami toolkit will require following data:

- Height information at 0.5 m/1 m vertical interval
- Land use / Land cover data
- Socio-economic data such as Age Group, Gender, Crops, Economy, Livelihood etc. should be made available by District Authorities in coastal areas and from District to State and to NSDI for consolidation and updation.
- Infrastructure and Housing
- Identification of sensitive parameters for Tsunami Risk Management (factors impacting the Risk)

Keeping in view the requirement of detailed GIS databases in a short duration of 2 years, the work can be done by these organizations and/or outsourced. The height data can be made available to authorised institutions for restricted use.

The databases similar to yellow pages listings need to be built up spatially. Thematic maps need to be developed where information on the location of large buildings that can serve as relief camps (schools, multi-purpose halls), warehouses, location of construction-equipment including bulldozers and cranes; hospitals etc., as well as lists of trained doctors, plumbers, electricians should be compiled and updated constantly and should be made available to the officials who are responsible for disaster response and to other response agencies.

There is a need to develop a mechanism to collect, collate, store and disseminate information relating to tsunami risk management. Post tsunami database generated by various government agencies, NGOs, international research institutions, international donors etc. on many development and disaster related issues, will be very useful to prepare integrated coastal zone management plans as well as to address the issue of disaster risk reduction in coastal areas.

Modelling

The data modelling for tsunami disaster management would require database related to land as well as shallow water components. It has to be an integrated database consisting of the following elements:

- Identification/ mapping of tsunami-genic sources
- Wave-characteristics
- Bathymetry
- 10 meter height to be mapped at 1:10,000 scale on a contour interval 1-m and 1:2,000 scale of selected areas at 0.5-m contour interval
- Data from National Tidal Centre (Geodetic & Research Branch, SOI, Dehradun),
- Data buoys from NIOT etc.

The above database has to be developed by collecting the relevant information from different institutions. Hence, a nodal person from such institutions has to be identified for not only providing data but also for validation of information system. The database will lead to preparation of tsunami hazard zonation and vulnerability maps for detailed risk assessment. Such initiatives should result into preparation of simple maps for public as well as highly technical maps for disaster mitigation.

National Database for Emergency Management (NDEM)

National Database for Emergency Management (NDEM) is conceived as a GIS based repository of real/ near real time data to support disaster/ emergency management in the country. This database, which will leverage much on the aerospace data, will have core data, hazard-specific data, and dynamic data in spatial as well as non-spatial forms. The Committee of Secretaries (COS) has entrusted the task of designing, developing and implementing NDEM to Department of Space (DoS). The National Remote Sensing Centre (NRSC) of DoS is the lead agency to implement and operationalise NDEM. As the different datasets ingesting into the NDEM are generated or collected from different organizations/ agencies, the NDEM is to be implemented through a coordinated effort. The NDEM will contain datasets at different scales/ details as follows.

(i) National level core geo-spatial data at 1:50,000 scale;

(ii) Hazard specific data for multi-hazard prone districts at 1:50,000 scale;

(iii) Data for multi-hazard prone cities/ towns at 1:10,000 scale; and

(iv) Data for major cities at 1:2,000 scale.

The database should enable development of decision support system in the form of customized user interfaces. These spatial databases will also have relevant attribute data required together for emergency management. Necessary security mechanisms should also be in place, so that the database is accessible to only authorized persons. The scope of NDEM encompasses all possible disasters of both natural as well as human-induced/ technological disasters/emergencies. Developing a GIS-based national database and application of geospatial technologies are considered central to the effective realization of goals under NDEM. In order to implement the NDEM, it is proposed to use national level GIS database, systems and network infrastructures to comprehensively support all the predicted emergency/ disaster management activities in a highly secure and reliable environment. The NDEM nodes can be generalized into four types: Data provider nodes, User nodes, NRSC node and MHA node. The NDEM database access is limited to the closed group of NDEM participating agencies. Since the NDEM database is a repository of highly sensitive spatial data including the high-resolution 1:2000 scale data sets, much higher level of data security is proposed.

The Steering Committee for NDEM, chaired by Secretary (Home), MHA, oversees the implementation of NDEM, and provides guidance and coordination at Ministry/ Department levels. The Technical Group (TG), constituted by MHA with Director, NRSC at chair, has the responsibility to work out the mechanism and modalities for successful implementation of the NDEM in a coordinated manner.

Toolkit for Public Awareness

NDMA has already taken several initiatives to increase awareness among the public through TV shots/ radio clippings, newspapers and by organizing events. Perhaps, media has to be involved in a bigger way so that information could reach deep into interior and to the target population.

The public awareness should also be carried out through marking high of high flood levels, sign boards, large scale maps mounted on boards for the escape routes for people as well as through public drills etc.

Framework for ICT

India has developed Information and communication technology to a great extent. The Department of Information Technology has prepared a comprehensive project as a part of the National e-Governance Plan to establish 100,000 Common Service Centres (CSCs) in village clusters to provide educational, information and transactional services. It is envisaged that by 2012, the CSC network will be expanded to 250,000 locations. Such Infrastructure will be used for creating greater public awareness on various aspects of disaster management as well. Other popular media are as follows:

- HAM Radio
- FM and AM Radio
- Community Radio
- TV and cable television
- Cell phone, Pagers

All kind of information systems will be used for purpose of disaster management. However, all time functioning of such technologies in pre- and post-disaster phase need to be ensured. Initiatives should also be taken to find out new technologies which would be more effective and sustainable during disaster and should be linked with GIS database.

Type of Tsunami Centres

The tsunami centres established for the tsunami risk management or multi-purpose centres in coastal areas should be equipped with facilities, such as HAM radio, transistor radio, TV set, landline/mobile phones, Internet/ email, medical kit, inoculation kit, purification/ chlorination kit, food (basic ration) & drinking water, milk-powder, electric generators, public address system, etc. To manage these tsunami centres, proper man-power requirements and participation of local communities should also be assessed. Proper maintenance of these multi-purpose centres is extremely important so that they are in usable condition in emergency situations.

Research & Development

The toolkit for research and development should not be developed in isolation and should be linked with R&D work being carried out in various research institutes such as IITs, NITs as well as projects sponsored by DST, CSIR etc. More coordinated efforts are required among these research institutes. Any research done should translate into end user benefits. Directory of scientific and technical institutions and their resource persons along with their contact details, i.e., phone numbers, fax-numbers, email ID etc. should be prepared and made available to concern people. In addition to R&D activities, training should be carried out for development of GIS database at district level with immediate initiation in priority districts.

Annexure-II
Tsunami Related Information

What is a tsunami?

- A tsunami is a series of waves with a long wavelength and period (time between crests). Time between crests of the wave can vary from a few minutes to over an hour.
- Tsunamis are often incorrectly called tidal waves; they have no relation to the daily ocean tides.
- Tsunami (soo-NAH-mee) is a Japanese word meaning harbour wave.
- Tsunamis can occur at any time of day or night.

How are tsunamis generated?

- Tsunamis are generated by any large, impulsive displacement of the sea bed level (Fig.1.1A)..
- Earthquakes generate tsunamis by vertical movement of the sea floor. If the sea floor movement is horizontal, a tsunami is not generated. Earthquakes of M 6.5 are critical for tsunami generation.
- Tsunamis are also triggered by landslides into or under the water surface, and can be generated by volcanic activity and meteorite impacts.

Fig.2.1 A:
Wave train of Tsunami

Source:- International Tsunami Information Centre - Geologic Hazard

How often do tsunamis occur?

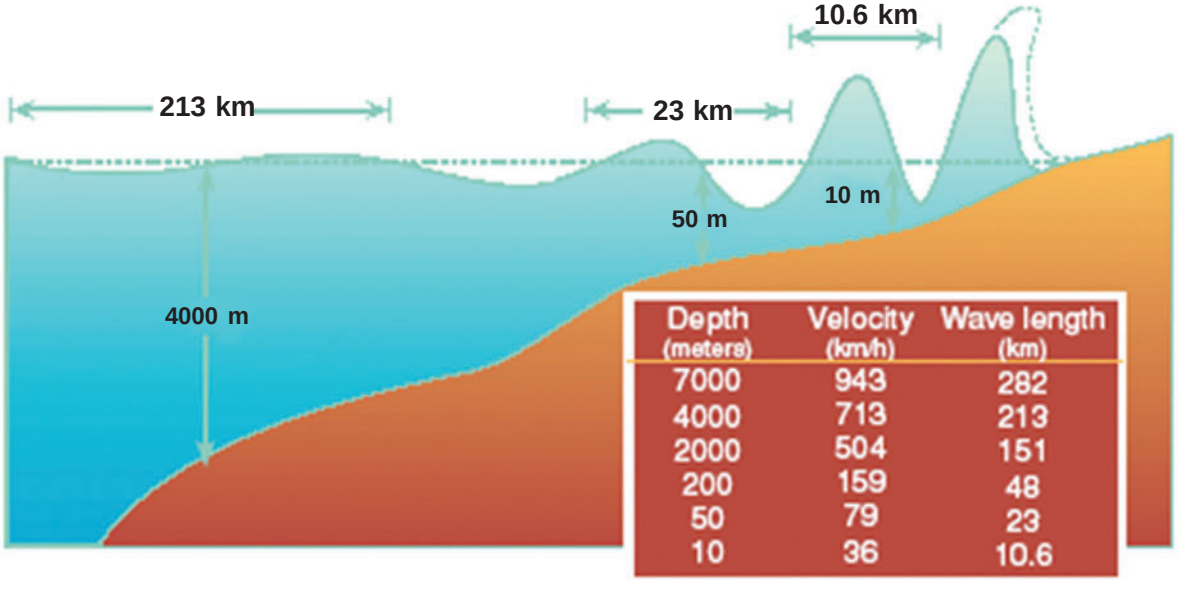
- On the average, there are two tsunamis per year in the Pacific Ocean somewhere, which cause damage near the source.
- Approximately every 15 years a destructive tsunami occurs in Pacific.
- The destructive tsunami on 26th December 2004 on the Indian Coast in terms of its impact seems to have

occurred for the first time in the history in the coastal districts of India. The geological studies are expected to throw light on the recurrence of such tsunamis.

How fast does a tsunami travel?

- Tsunami velocity is dependent on the depth of water through which it travels (Velocity equals the square root of water depth (h) times the gravitational acceleration g, that is V = g h).
- Tsunamis travel approximately at a velocity of 700 kmph in 4000 m depth of sea water. In 10 m of water depth the velocity drops to about 36 kmph. See Fig.2

Fig. 2.2 A:
Tsunami Velocities



Source:http://www.prh.noaa.gov/pr/itic/library/pubs/great_waves/tsunami_great_waves_4.html

- For example, the tsunami from Sumatra coastal earthquake travelled to Tamil Nadu coast in about two hours.
- Even on shore tsunami speed is 35 - 40 km/h, hence much faster than a person can run.

How big is a tsunami?

- Tsunamis range in size from centimeters to over 30 m height. Most tsunamis are less than 3 m in height.
- In deep water (greater than 200 m), tsunamis are rarely over 1m high and will not be noticed by ships due to their long period (time between crests).
- As tsunamis propagate into shallow water, the wave height can increase by over 10 times.
- Tsunami heights can vary greatly along a coast. The waves are amplified by certain shoreline and bathymetric (sea floor) features.

- A large tsunami can flood land up to1.5 km from the coast.
- The force of some tsunamis is enormous. Large rocks weighing several tons along with boats and other debris can be moved inland hundreds of feet by tsunami wave activity. Homes and other buildings are destroyed. All this material and water move with great force and can kill or injure people.

What does a tsunami look like when it reaches shore?

- Normally, a tsunami appears as a rapidly advancing or receding tide.
- It some cases a bore (wall of water) or series of breaking waves may form.
- Sometime a tsunami causes the water near the shore to recede by 0.5 - 2.0 km, exposing the ocean floor, then the wave crest comes with a high speed.
- Tsunamis can travel up to interior of river through mouths and streams that lead to the sea.

How is a tsunami different from a wind-generated wave?

- Wind-generated waves usually have periods (time between crests) of 5 to 20 seconds. Tsunami periods are usually between 5 minutes and an hour.
- Wind-generated waves break as they shoal and lose energy offshore. Tsunamis act more like a flooding wave. A 6 m tsunami is a 6 m rise in sea level. This rise is temporary.

Local Tsunami: Local tsunamis are generated nearby in the ocean and strike the shore quickly within minutes. It does not provide time for official evacuation. The damage is observed due to earthquake ground vibration and tsunami wave actions.

Distant Tsunami: These are generated far away in the ocean and provide sufficient time for official evacuation before it strikes the shore. It causes wide spread damage. Large tsunami waves generated by Chilean earthquake (1960) travelled across the Pacific Ocean and reached to the Japanese coast 22 hrs. after the earthquake occurred. About 140 people were killed or missing by this tsunami in Japan.

Tsunami risk

By integrating the hazard and vulnerability assessments, the tsunami risk assessment is to be developed in terms of zonation and inundation maps and associated affects. It will be assessed by a deterministic approach according to the following:

TSUNAMI RISK = TSUNAMI HAZARD x EXPOSURE x VULNERABILITY.

(a) For the Tsunami Hazard assessment:

- Preparation of data-base of historical and archival information (newspapers, archives, anecdotal information, literature survey) of relevant Indian Tsunamis, with the emphasis clearly on the 26th December 2004 event.

- Supplement the data from computer based simulations.
- Analyses of these data, to define the scenario Tsunamis from various earthquake sources
- Prepare the Tsunami hazard map.

(b) For the Exposure

- List all habitations below 10 m contour level and locate on a map.
- List and locate all vital installations below 10 m contour level (Ports, Harbours, Schools, Hospitals, Power Plants, Bridges, etc.)

(c) For the VULNERABILITY assessment:

- Based on the earthquake vulnerability assessment, define the vulnerability of various exposed elements on the coastal, island and reef environments and in the Ports and Harbours
- Prepare vulnerability maps (based on Remote Sensing, Geographical information system and other data related to various hazards).

(d) For the RISK assessment:

- Integrate these hazard and exposure data with vulnerability assessments to obtain the risk assessment.

Scenario Tsunami

The following parameters will need to be defined:

- Tsunami source region:
- Mode of generation:
- Potential wave heights
- Maximum Run-up (maximum height of the water onshore observed/inferred above the mean sea level. Usually measured at the horizontal inundation limit)
- Tsunami intensity I=0.5 log 2H
- with H = average maximum run-up height >3 m. Imax = 2.5

Tsunami Hazard Map

The tsunami hazard map may be empirically defined using a deterministic approach, based upon potential maximum wave heights for the scenario tsunamis. Where found applicable, remote sensing and GIS may be used. The definition of the tsunami hazard zones, as preliminary estimates, is given in Table 1.1 A. For the terrestrial environment the hazard may be presented as inundation levels, in terms of run-up heights at specified land contours. For the marine environment ("ON WATER") Harbour, Bay and Reefs - hazard may be given in terms of potential maximum wave heights.

Table 2.1 A:
Tsunami Hazard Zones Definition (Preliminary)

CHARACTERISTIC	TSUNAMI HAZARD ZONE		
	HI	MED	LOW
ON LAND Inundation Level Maximum (m Contour)	>5	3-5	1-3
Run Up Height (Average) (m)	>3	1-3	0-1
Tsunami Intensity (I)	>2	1-2	0
Likelihood of Tsunami	Yes	Yes	Possible
Damage Observed in Earlier Tsunami	Severe	Minor	None
Coast Adjacent to Tsunamigenic Source	Yes	Yes	No
ON WATER Wave Heights (m)	>2	1-2	<1
Reef Damage	Severe	Minor	None

Practical Applications

The key factors to reduce potential losses due to tsunami are AWARENESS and PREPAREDNESS. In both quantitative and qualitative terms, the practical applications of tsunami risk assessment for implementation of mitigation strategies of terrestrial and marine environments include:

1	Building Codes		(potential damage due to wave action and flooding)
2.	GIS Mapping		
3.	Land-Use Planning		(taking note of wave action & flooding)
4.	Disaster Planning		(in identified hazard zones)
5.	Emergency Management		
6.	Emergency Personnel Training		(necessary aspects relevant to marine situations)
7.	Rescue and Response (marine situations related to shipping)		(cargo, tourist, inter-islands fishing community, recreational boating)
8.	Insurance Needs		
9.	Community Education		
10.	Simulated Tsunami Exercises		

Annexure-III

Tsunamis in India

The Indian coastal belt has not recorded many severe tsunamis in the past. Waves accompanying earthquake activity have been reported over the North Bay of Bengal. During an earthquake in 1881 which had its epicentre off Nicobar in the Bay of Bengal, tsunamis were reported. The earthquake of 1941 off middle Andaman caused some damage in the region but no reliable reports are available on the tsunami. This was unusual because most Tsunamis are generated by shocks which occur at or near the flanks of continental slopes. During the earthquakes of 1819 and 1845 near the Rann of Kutch, there were rapid movements of water into the sea. There is no mention of waves resulting from these earthquakes along the coast adjacent to the Arabian Sea, and it is unlikely that tsunamis were generated. Further west, in the Persian Gulf, the 1945 Makran earthquake (magnitude 8.1) generated Tsunami of 12 to 15 metres height. This caused a huge deluge, with considerable loss of life and property at Ormara and Pasi. The estimated height of tsunami at Gulf of Kutchch was 15m but no report of damage is available. The estimated height of waves was about 2 metres at Mumbai, where boats were taken away from their moorings and casualties occurred. A list showing the tsunami that affected Indian coast in the past is given in Table-3.2. The information given in the Table for the first three events is sketchy and authenticity cannot be confirmed except the tsunami of 26th December 2004.

Above facts indicate the coastal region of Gujarat is vulnerable to tsunamis from great earthquakes in Makran coast. Earthquake of magnitude 7 or more may be dangerous. It may be noted that all earthquake do not generate tsunami. research is still being undertaken in this field. For the Indian region, two potential sources have been identified, namely Makran coast and Andaman to Sumatra region. Following are some tsunamigenic earthquakes which affected Indian coast lines.

December 31, 1881 Earthquake

An earthquake of magnitude M 7.9 occurred beneath the ocean which caused damaged to some masonry buildings at Port Blair. Tsunamis triggered by this earthquake are reported to have caused a 1.2m run up on the east coast of India.

June 26, 1941 Port Blair Earthquake

An earthquake of magnitude M 8.1 struck Port Blair. It was the strongest recorded earthquake from the Andaman. The tower of the cellular jail broke down, killing the chief warden. The tsunamis triggered by this earthquake is reported to have inundated the west coast of Andaman. The region was inhabited mostly by the Jarawa tribes, who had no means of reporting. However, although, the earthquake was well recorded in India, no reliable tsunami reports are available. It is possible that this earthquake may not have generated large tsunami, going by the lack of press reports.

January 20, 1982 Great Nicobar Earthquake

An earthquake of magnitude Ms 6.3; occurred at 4h 25m 12.7s GMT at a focal depth of 28 km located at East coast of Great Nicobar Island. The maximum intensity observed - VIII. Caused wide spread damage to civil engineering structures. Caused great panic among the ex-servicemen settlers (300 - 1969).

December 26, 2004 Sumatra Earthquake

A great Tsunamigenic earthquake measuring 9.3 on Richter Scale (MW = 8.2) having a focal depth of 10 km struck Northern Sumatra, Indonesia at 00:58:50 UTC on Dec. 26, 2004 accompanied by several strong aftershocks having magnitude ranging from 5.0 to 7.3 and with epicentral locations ranging from west coast northern Sumatra to Andaman-Nicobar islands, Indian region. The main shock near Sumatra generated tsunami that hit the Andaman and Nicoboar Islands and caused extensive damage to lives and property. The official death toll in India has risen to more than 15500.

Table -3.1 A:
Lives Lost in Some Major Tsunamis

Year	Place	Number of Lives lost
1692	Port Royal, Jamaica	3000
1703	Tsunamis in Honshu, Japan following a large earthquake	5000
1707	38 foot Tsunami, Japan	30,000
1741	Following Volcanic eruptions 30 feet wave in Japan	1400
1st November 1775	The great Lisbon earthquake generated a wave up to 20 feet high that struck coastal Portugal, Spain and Morocco	50,000
1783	A Tsunami in Italy	30,000
1868	Tsunami in Chile and Hawaii	Morethan 25000
27th August 1883	The eruption of the volcano Krakatau generates a massive waves that sweeps over shores of nearby Jawa and Sumatra	36,000
15th June 1896	The Sanriku tsunami strikes Japan without warning. A wave estimated of more than 70 feet high hits a crowd gathered to celebrate a religious festival	27,000
17th December 1896	Tsunami washes away part of the embankment and main boulevard of Santa Barbara	27,000

Year	Place	Number of Lives lost
31st January 1906	A devastating offshore quake submerged part of Tumaco, Colombia and washes away every house on the coast between Riover de, Ecuador, and Mkay, Columbia. Death toll estimated at 500 to 1500	1500
1933	Tsunami, Sanriku Japan	3000
1946	Alaskan earthquake generates a tsunami that destroys North Cape lighthouse, killing five. Hours later the waves arrives at Hilo, Hawaii killing 159 people and causing enormous damage.	159
22nd May 1960	A wave reportedly up to 35 feet high kills 1000 people in Chile and causes damage in Hawai, the Philippines and Okinawa, Japan as it sweeps across the Pacific	Approx. 2000 (+3000 persons missing).
1946	Honshu, Japan Earthquake Tsunami	2000
28th March 1964	Good Friday earthquake in Alaska sends out a wave swamping much of the Alaskan coast and destroying three villages. The waves kill 107 people in Alaska, four in Oregon and 11 in California as it sweeps down the west	131
16th August 1976	Tsunami kills more than 5000 people in the Moro gulf region of the Philippines	8000
19th August 1977	Indonesia	189
18th July 1979	Indonesia	540
12th September 1979	New Guinea	100
12th December 1979	Columbia	500
26th May 1983	Sea of Japan	Approx. 100
17th July 1998	An offshore earthquake triggers a wave that strikes the north cost of Papua New Guinea killing 2000 people and leaving thousands more homeless	2000

Table 2.2 A:
List of Tsunamis that Affected India

S.No.	Year	Remarks
1	326 B.C.	First recorded tsunami Alexander the Great
2	Between 1st April and 27th May 1008	Tsunami on the Indian coast from a local earthquake
3	12th April 1762	Earthquake in the Bay of Bengal generated tsunami wave of 1.8 m in coastal Bangladesh
4	19th August 1868	Earthquake Mw 7.5 in the Bay of Bengal. Tsunami wave run-up level at Port Blair, Andaman Island 4.0 m.
5	31st December 1881	Earthquake of magnitude Ms 7.9 in the Bay of Bengal, reported tsunami run-up level of 0.76m at Car Nicobar, 0.3m at Dublat , 0.3 m at Nagapattinam and 1.22 m at Port Blair in Andaman & Nicobar Islands
6	1883	Karakatau, volcanic explosion in Indonesia. 1.5 m tsunami at Chennai, 0.6 m at Nagapattinam and also surges at Calcutta harbour.
7	1884	Earthquake in the western part of the Bay of Bengal. Tsunamis at Port Blair & mouth of Hooghly River
8	26th June 1941	Earthquake of magnitude MW 8.1 in the Andaman Sea at 12.90 N,92.5o E. No reliable data on the resultant tsunamis on the east coast of India. Although there is some unverifiable reports, no press reports of any tsunami related damage from East Coast.
9	27th November 1945	Makran Earthquake (Magnitude Ms 8.3). 12 to 15 M wave height in Ormara, 13 m at Pasni, and 1.37 m at Karachi (Pakistan) . In Gulf of Cambay of Gujarat wave height of 11.0 m was estimated, and 2 m at Mumbai, where boats were taken away from their moorings.
10	26th December 2004	An earthquake of high Magnitude (MW 9.3) generated giant tsunami waves in North Indian Ocean. Tsunami made extensive damage to many coastal areas of Indonesia, India, Malaysia, Maldives, Sri Lanka and Thailand. More than 200,000 people lost their lives in 14 countries in the Indian Ocean region.

Multi-Hazard Situation in Coastal States/UTs

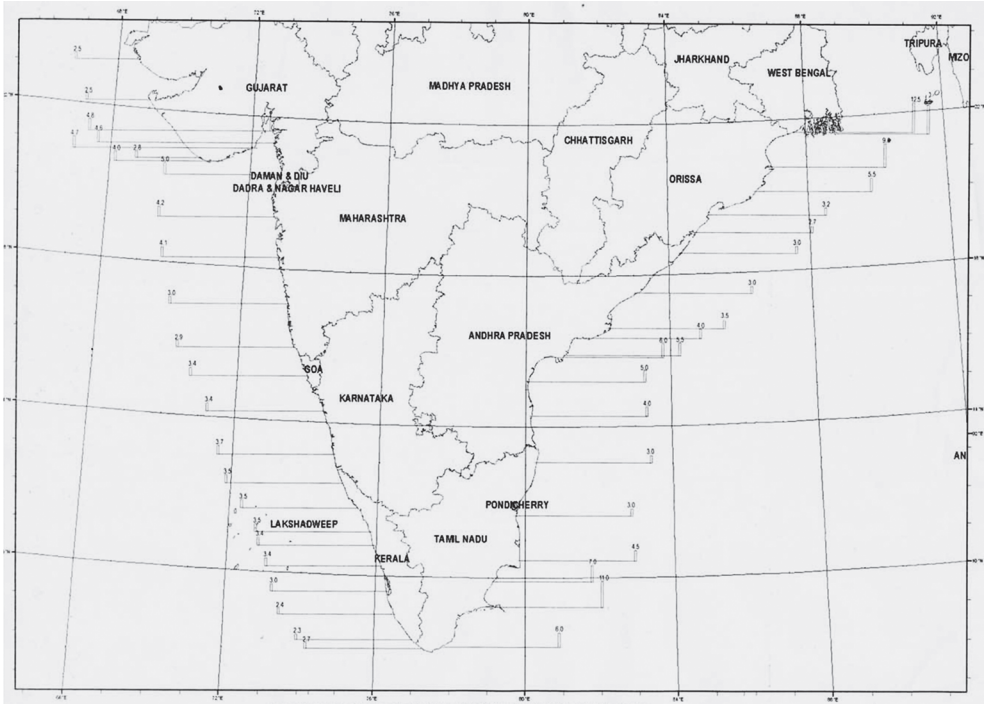
The following natural hazards are seen to occur in the coastal areas of India:

1. Earthquakes
2. Cyclonic wind
3. Storm surge in cyclones
4. Flooding by incessant rain
5. Tsunami

Tsunami Early Warning System (TEWS) in other parts of the world

The Intergovernmental Oceanographic Commission (IOC) of UNESCO established the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) in 1968, which operates the Pacific Tsunami Warning System. Pacific Tsunami Warning Centre (PTWC) provides international warnings on Pacific-wide tsunamis after the occurrence of the earthquake and it is effective for communities located at least several hundred kilometres from the source region. Regional systems such as those operated by the USA, Japan, the Russian Federation, France and Chile provide primarily domestic warnings within about 10-15 minutes of earthquake and are effective for communities located at least a 100 km from the source region. Local systems operated by Japan and Chile are capable of providing a warning in about 5 minutes to give some measure of protection to communities located within a 100 km of the source.

While the Pacific Tsunami Warning Centre (PTWC) could provide the Indian Ocean countries with (a) earthquake information, epicentre, magnitude, (b) a general statement about the potential for tsunami generation and (c) estimated arrival times of initial wave, it is quite clear that it cannot provide (a) confirmation that tsunami actually exists, (b) forecast of tsunami strength and (c) warning cancellation.



Map showing the Probable Maximum Storm Surge Level in Different Coastal States of India

Annexure-IV

Coastal Area Classification and Development Control Regulations

Classification of Coastal Regulation Zone:

6(1) For regulating development activities, the coastal stretches within 500 metres of High Tide Line on the landward side are classified into four categories, namely:

Category I (CRZ-I):

(i) Areas that are ecologically sensitive and important, such as national parks/ marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/historically/ heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/Union Territory level from time to time.

(ii) Area between Low Tide Line and the high Tide Line.

Category II (CRZ-II):

The areas that have already been developed up to or close to the shoreline. For this purpose, "developed area" is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

Category-III (CRZ-III):

Areas that are relatively undisturbed and those which do not belong to either Category-I or II. These will include coastal zone in the rural areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

Category-IV (CRZ-IV):

Coastal stretches in the Andaman & Nicobar, Lakshadweep and small islands, except those designated as CRZ-I, CRZ-II or CRZ-III

Norms For Regulation of Activities.

Category - III (CRZ-III):

(i) The area up to 200 metres from the High Tide Line is to be earmarked as 'No Development Zone*.

[Provided that such area does not fall within any notified port limits or any notified Special Economic Zone.]

[No construction shall be permitted within this zone except for repairs of existing authorised structures not exceeding existing FSI, existing plinth

area and existing density, and for permissible activities under the notification including facilities essential for such activities.] However, the following uses/activities may be permissible in this zone - agriculture, horticulture, gardens, pastures, parks, play fields, forestry, ^[mining of rare minerals] and salt manufacture from sea water.

(ii) Development of vacant plots between 200 and 500 metres of High Tide Line in designated areas of CRZ-III with prior approval of Ministry of Environment and Forests (MoEF) permitted for construction of hotels each resorts for temporary occupation of tourists/visitors subject to the conditions as stipulated in the guidelines at Annexure-II.

[Construction/reconstruction of dwelling units between 200 and 500 metres of the High Tide Line permitted so long it is within the ambit of traditional rights and customary uses such as existing fishing villages and gaothans. Building permission for such construction/reconstruction will be subject to the conditions that the total number of dwelling units shall not be more than twice the number of existing units; total covered area on all floors shall not exceed 33 percent of the plot size; the overall height of construction shall not exceed 9 metres and construction shall not be more than 2 floors ground floor plus one floor. Construction is allowed for permissible activities under the notification including facilities essential for such activities. An authority designated by State Government/ Union Territory Administration may permit construction of public rain shelters, community toilets, water supply, drainage, sewerage, roads and bridges. The said authority may also permit construction of schools and dispensaries, for local inhabitants of the area, for those panchayats the major part of which falls within CRZ if no other area is available for construction of such facilities].

Annexure-V

Protection against Tsunami/Cyclone Mitigation

To achieve the satisfactory level of tsunami disaster mitigation in coastal areas, following activities need to be carried out:

- Review of Coastal Zone Regulation Act in wake of tsunami storm surge hazards and strict implementation of the same may be carried out by the respective State Disaster Management Authorities. A special task force for this purpose may be constituted comprising of the representatives from various departments of the government and other relevant organizations (e.g. Departments of Forestry, Fisheries, Soil Conservation, Town and Country Planning Organization, Navy, Coast Guard, IMD, ISRO/DoS, SOI, GSI etc.)
- A state of the art EOC may be established within the authority for monitoring purpose.
- Initiating disaster watch (bay watch) safety measures along important beaches in the country, providing round the clock monitoring, warning, lifeguard facilities & creation of website for missing personal etc.
- Organization of sensitization workshops on cyclone/tsunami risk mitigation in various states for senior bureaucrats / politicians for these states.
- Organizing drills on regular basis to check the viability of all plans and to check the readiness of all concerned
- Training of professionals, policy planners and others involved with disaster mitigation and management programmes in the states
- Retrofitting of important buildings
    - o Fire stations / police stations/ army structures/ hospitals
    - o VIP residences / offices/ railways, airport, etc.
    - o Schools/colleges
    - o Hazardous industries
    - o Other critical structures (i.e. power stations, warehouses, oil and other storage tanks etc)
- Designing incentives: Providing legislative back up to encourage people to adopt cyclone, tsunami resistant features in their homes e.g. tax rebate in terms of house tax and/ or income tax.
- Developing public -private partnerships.

Annexure-VI

Do's and Don'ts for Protection from Tsunami

If you are in an area at risk from tsunamis

- *You should find out if your home, school, workplace, or other frequently visited locations are in tsunami hazard areas.*
- *Know the height of your street above sea level and the distance of your street from the coast or other high-risk waters.* (Local administration may put sign boards).
  Evacuation orders may be based on these numbers. Also find out the height above sea level and the distance from the coast of outbuildings that house animals, as well as pastures or corrals.
- *Plan evacuation routes from your home, school, workplace, or any other place you could be where tsunamis present a risk.*
  If possible, pick areas (30 meters) above sea level or go as far as 3 kilometres inland, away from the coastline. If you cannot get this high or far, go as high or far as you can. Every meter inland or upward may make a difference. You should be able to reach your safe location on foot within 15 minutes. After a disaster, roads may become blocked or unusable. Be prepared to evacuate by foot if necessary. Footpaths normally lead uphill and inland, while many roads parallel coastlines. Follow posted tsunami evacuation routes; these will lead to safety. Local emergency management officials can advise you on the best route to safety and likely shelter locations.
- *If your children's school is in an identified inundation zone, find out what the school evacuation plan is.*
  Find out if the plan requires you to pick your children up from school or from another location. Telephone lines during a tsunami watch or warning may be overloaded and routes to and from schools may be jammed.
- *Practice your evacuation routes.*
  Familiarity may save your life. Be able to follow your escape route at night and during inclement weather. Practicing your plan makes the appropriate response more of a reaction, requiring less thinking during an actual emergency situation.
- *Use a Weather Radio or stay tuned to a local radio or television station to keep informed of local watches and warnings.*
- *Talk to your insurance agent.*
  Homeowners' policies may not cover flooding from a tsunami. Ask the Insurance Agent about the benefits from Multi-Hazard Insurance Schemes.

- *Discuss tsunamis with your family.*
  Everyone should know what to do in a tsunami situation. Discussing tsunamis ahead of time will help reduce fear and save precious time in an emergency. Review flood safety and preparedness measures with your family.

If you are visiting an area at risk from tsunamis

Check with the hotel or campground operators for tsunami evacuation information and find out what the warning system is for tsunamis. It is important to know designated escape routes before a warning is issued.

One of the early warning signals of a tsunami is that the sea water recedes several metres, exposing fish on shallow waters or on the beaches. If you see the sea water receding, you must immediately leave the beach and go to higher ground far away from the beach.

Protect Your Property

You should avoid building or living in buildings within 200 meters of the high tide coastline.

These areas are more likely to experience damage from tsunamis, strong winds, or coastal storms.

- *Make a list of items to bring inside in the event of a tsunami.*

  A list will help you remember anything that can be swept away by tsunami water.

- *Elevate coastal homes.*

  Most tsunami waves are less than 3 meters. Elevating your house will help reduce damage to your property from most tsunamis.

- *Take precautions to prevent flooding.*
- *Have an engineer check your home and advise about ways to make it more resistant to tsunami water.*
  There may be ways to divert waves away from your property. Improperly built walls could make your situation worse. Consult with a professional for advice.
  Ensure that any outbuildings, pastures, or corrals are protected in the same way as your home. When installing or changing fence lines, consider placing them in such a way that your animals are able to move to higher ground in the event of a tsunami.

What to Do if You Feel a Strong Coastal Earthquake

If you feel an earthquake that lasts 20 seconds or longer when you are in a coastal area, you should:

- Drop, cover, and hold on.
  You should first protect yourself from the earthquake damages.
- When the shaking stops
  Gather members of your household and move quickly to higher ground away from the coast. A tsunami may be coming within minutes.
- Avoid downed power lines and stay away from damaged buildings and bridges from which Heavy objects might fall during an aftershock.

If you are on land

Be aware of tsunami facts. This knowledge could save your life! Share this knowledge with your relatives and friends. It could save their lives!

- If you are in school and you hear there is a tsunami warning, you should follow the advice of teachers and other school personnel.
- If you are at home and hear there is a tsunami warning, you should make sure your entire family is aware of the warning. Your family should evacuate your house if you live in a tsunami evacuation zone. Move in an orderly, calm and safe manner to the evacuation site or to any safe place outside your evacuation zone. Follow the advice of local emergency and law enforcement authorities.
- If you are at the beach or near the ocean and you feel the earth shake, move immediately to higher ground, DO NOT wait for a tsunami warning to be announced. Stay away from rivers and streams that lead to the ocean as you would stay away from the beach and ocean if there is a tsunami. A regional tsunami from a local earthquake could strike some areas before a tsunami warning could be announced.
- Tsunamis generated in distant locations will generally give people enough time to move to higher ground. For locally-generated tsunamis, where you might feel the ground shake, you may only have a few minutes to move to higher ground.
- High, multi-storied, reinforced concrete hotels are located in many low-lying coastal areas. The upper floors of these hotels can provide a safe place to find refuge should there be a tsunami warning and you cannot move quickly inland to higher ground.
- Homes and small buildings located in low-lying coastal areas are not designed to withstand tsunami impacts. Do not stay in these structures should there be a tsunami warning.
- Offshore reefs and shallow areas may help break the force of tsunami waves, but large and dangerous wave can still be a threat to coastal residents in these areas.

  Staying away from all low-lying areas is the safest advice when there is a tsunami warning.

If you are on a boat

Since tsunami wave activity is imperceptible in the open ocean, do not return to port if you are at sea and a tsunami warning has been issued for your area. Tsunamis can cause rapid changes in water level and unpredictable dangerous currents in harbours and ports.

If there is time to move your boat or ship from port to deep water (after a tsunami warning has been issued), you should weigh the following considerations:

- Most large harbours and ports are under the control of a harbor authority and/or a vessel traffic system. These authorities direct operations during

periods of increased readiness (should a tsunami be expected), including the forced movement of vessels if deemed necessary. Keep in contact with the authorities should a forced movement of vessel be directed.

- Smaller ports may not be under the control of a harbor authority. If you are aware there is a tsunami warning and you have time to move your vessel to deep water, then you may want to do so in an orderly manner, in consideration of other vessels.
- Owners of small boats may find it safest to leave their boat at the pier and physically move to higher ground, particularly in the event of a locally-generated tsunami.
- Concurrent severe weather conditions (rough seas outside of safe harbor) could present a greater hazardous situation to small boats, so physically moving yourself to higher ground may be the only option.
- Damaging wave activity and unpredictable currents can affect harbours for a period of time following the initial tsunami impact on the coast. Contact the harbor authority before returning to port making sure to verify that conditions in the harbor are safe for navigation and berthing.

What to do after a Tsunami

- *You should continue using a Weather Radio or staying tuned to a Coast Guard emergency frequency station or a local radio or television station for updated emergency information.*

The Tsunami may have damaged roads, bridges, or other places that may be unsafe.

- *Check yourself for injuries and get first aid if necessary before helping injured or trapped persons.*
- *If someone needs to be rescued, call professionals with the right equipment to help*
  Many people have been killed or injured trying to rescue others in flooded areas.
- Help people who require special assistance-
  Infants, elderly people, those without transportation, large families who may need additional help in an emergency situation, people with disabilities, and the people who care for them.
- *Avoid disaster areas.*
  Your presence might hamper rescue and other emergency operations and put you at further risk from the residual effects of floods, such as contaminated water, crumbled roads, landslides, mudflows, and other hazards.
- *Use the telephone only for emergency calls.*
  Telephone lines are frequently overwhelmed in disaster situations. They need to be clear for emergency calls to get through.
- *Stay out of a building if water remains around it.*
  Tsunami water, like floodwater, can undermine foundations, causing buildings to sink, floors to crack, or walls to collapse.

- *When re-entering buildings or homes, use extreme caution.*
  Tsunami-driven floodwater may have damaged buildings where you least expect it. Carefully watch every step you take.
- *Wear long pants, a long-sleeved shirt, and sturdy shoes.*
  The most common injury following a disaster is cut feet.
- *Use battery-powered lanterns or flashlights when examining buildings.*
  Battery-powered lighting is the safest and easiest to use, and it does not present a fire hazard for the user, occupants, or building. DO NOT USE CANDLES.
- *Examine walls, floors, doors, staircases, and windows to make sure that the building is not in danger of collapsing.*
- *Inspect foundations for cracks or other damage.*
  Cracks and damage to a foundation can render a building uninhabitable.
- *Look for fire hazards.*
  Under the earthquake action there may be broken or leaking gas lines, and under the tsunami flooded electrical circuits, or submerged furnaces or electrical appliances. Flammable or explosive materials may have come from upstream. Fire is the most frequent hazard following floods.
- *Check for gas leaks.*
  If you smell gas or hear a blowing or hissing noise, open a window and get everyone outside quickly. Turn off the gas using the outside main valve if you can, and call the gas company from a neighbour's home. If you turn off the gas for any reason, it must be turned back on by a professional.
- *Look for electrical system damage.*
  If you see sparks or broken or frayed wires, or if you smell burning insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice. Electrical equipment should be checked and dried before being returned to service.
- *Check for damage to sewage and water lines.*
  If you suspect sewage lines are damaged under the quake, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water from undamaged water heaters or by melting ice cubes that were made before the tsunami hit. Turn off the main water valve before draining water from these sources. Use tap water only if local health officials advise it is safe.
- *Watch out for wild animals*, especially poisonous snakes that may have come into buildings with the water. Use a stick to poke through debris. Tsunami floodwater flushes snakes and animals out of their homes.
- *Watch for loose plaster, drywall, and ceilings that could fall.*
- *Take pictures of the damage*, both of the building and its contents, for insurance claims. *Open the windows*

and doors to help dry the building.

- *Shovel mud before it solidifies.*
- *Check food supplies.*
  Any food that has come in contact with floodwater may be contaminated and should be thrown out.
- *Expect aftershocks*
  If the earthquake is of large magnitude (magnitude 8 to 9+ on the Richter scale) and located nearby, some aftershocks could be as large as magnitude 7+ and capable of generating another tsunami. The number of aftershocks will decrease over the course of several days, weeks, or months depending on how large the main shock was.
- Watch your animals closely.
  Keep all your animals under your direct control. Hazardous materials abound in flooded areas. Your pets may be able to escape from your home or through a broken fence. Pets may become disoriented, particularly because flooding usually affects scent markers that normally allow them to find their homes. The behaviour of pets may change dramatically after any disruption, becoming aggressive or defensive, so be aware of their well-being and take measures to protect them from hazards, including displaced wild animals, and to ensure the safety of other people and animals.

Annexure-VII

Need for Spatial Data for GIS in Coastal Areas

National contingency plans are useful means for communicating the risk and for initiating communal preparedness against known disasters. High quality spatial data is required for its effective implementation. Further, as vulnerability and hazard profiles change frequently, these tools have to be kept current for its effective utility by the concerned disaster management agency and the vulnerable community. Geo-spatial Technology, has systematized the approach for managing all phases of disaster, as the advancements in digital technologies have now made it possible to use diverse spatial databases in an integrated manner.

Topographic map database is the foundation of all spatial data. In India, the responsibility for producing, maintaining and disseminating the topographic map database for the whole country, rests with the Survey of India (SOI). Recently, SOI had been mandated to take a leadership role in liberalizing access of spatial data to user groups without jeopardizing national security. To perform this role, the policy on dissemination of maps and spatial data had been amended, making provision for the introduction of dual series maps viz. the Defence Series Maps (DSMs) and Open Series Maps (OSMs).

Defence Series Maps are the topographical maps on Everest/WGS-84 Datum and Polyconic/UTM Projection, on various scales, with heights, contours and full content without dilution of accuracy. This series of maps will mainly cater for defence and national security requirements and are appropriately classified, and their guidelines for use are formulated by the Ministry of Defence.

On the other hand, Open Series Maps brought out by the Survey of India, exclusively support social requirements and development activities. OSMs possess different map sheet numbers and are on UTM Projection on WGS-84 datum. Each map of this category will become "Unrestricted" after obtaining a one-time clearance of the Ministry of Defence. The content of the OSMs (Ref: National Map Policy 2005) are as follows:

SI.NO.	CATEGORY/LAYER		SUB DETAILS
1.	GENERAL		Latitude/Longitude Name of State/District/Administrative index Topo sheet Number/Year of Survey/Edition No./Index to topo sheets Magnetic variation from true North direction Map reference Bar scale/Representative Factor
2.	ADMINISTRATIVE BOUNDARIES	Names Boundary Boundary Pillars	Administrative/Locality or tribal International to village, Forest, all boundary pillars, village trijunctions

SI.NO.	CATEGORY/LAYER		SUB DETAILS
3.	COMMUNICATIONS/ ROADS	Roads Tracks Railways Embankments Other Lines	All Roads All Tracks, pass, footpath All gauges with stations, tunnels Light railways or tramway, All embankments, Road/rail/tank
4.	HYDROLOGY	Stream/Canals Dams Rivers & Banks Wells, Water Features	All streams/canals All earthwork dams All rivers with details, banks, islands All wells/tube wells/springs All Tanks (excluding overhead tanks), Lightship, buoys, anchorages
5.	SETTLEMENT/ CULTURAL DETAILS	Towns or Villages Offices Settlements	Village inhabited, deserted and forts Huts, Tower, Antiquities Religious places, tombs/grave All post/telegraphic/Police stations hutments All Bungalows
6.		TRANSMISSION LINE	
7.	RELIEF/ HYPSOGRAPHY	Contours Sand Features Ice Forms Heights Benchmarks	Contours with sub features All sand features Ice forms (all features) Spot height, Approximate height Bench marks (Geodetic tertiary, canal)
8.	VEGETATION	Plantations, Trees	All trees, Vine on trellis, grass, scrub.
9.	FOREST		Reserved/Protected

** Contours & heights will not be available in restricted zones as per MOD's instruction.*

In addition to the basic topographic data there are several other sets of data like the Hydrography, Meteorology, Demography, Geography and other Statistical data which are required for directing the contingency plans and also for effective post disaster response. Hence, data production, integration and dissemination systems that are dynamically linked using service architecture are proposed as the most practical means of ensuring that multi-sectoral disaster managers have access to the most current hazard and vulnerability information. Further, it should be ensured that the data being maintained is applicable for planning strategies for a wide variety of coastal disasters and is in proper format for easy integration and dissemination so that it reaches a wide spectrum of user agencies and field units in a

short turnaround time. The scale / frequency / resolution of the data should be appropriate for facilitating effective response planning at local and regional scale.

To minimize the response time and save precious life and property there is a need for preparation of Baseline Hazard and Vulnerability Profiles using historical data and modeling techniques to convert it to useful information which can further be integrated with the vulnerability profiles, so that a series of response plans for reducing the risk associated with various hazard scenarios could be prepared and stored. During actual hazard events, an appropriate risk profile is selected based on real time hazard and vulnerability information, and the associated activities included in the response plan are implemented. Satellite Data could be used for tracking the variations observed on the surface of the Sea.

Another important step is to train the managers and other related manpower to be familiar with the system that is developed so that at the time of disaster they can efficiently extract the required information and apply it in proper form for achieving the desired results.

NSDI could manage the data sets generated by various agencies / techniques (LIDAR, radar, GPS etc.) and NDMA could use this available data for vertical integration and generation of relevant knowledge / vulnerability maps / action plan / contingency plans etc. Mission mode initiatives involving resource personnel / agencies and other stake holders have to be carried out to improve the necessary inputs for disaster management.

Preparedness phase - Hazard Potential Maps - Historical precedent, proximity (to hazard viz. near coast, river, power generation station etc.), trends and indications (windspeed /rain - cyclone), location of escape routes, shelters etc.

Early Warning Phase - Generation and transfer of actionable information to disaster managers and vulnerable community (population / industry / economic activity). Integration of hazard and vulnerability information - for generation of risk assessment and warning - minimize loss.

Response Phase - Minimise loss of life due to secondary hazards.

Barriers and issues in Technology deployment - Need to resolve it -

Scientific Problems

- Lack of data
- Inadequate data sharing
- Poor communication of data
- Duplication of data
- Physical environment

Social Problems

- Political problems
- Government structure
- Relocation of people
- Inequity
- Cultural issues
- Demography

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